JUNTOS

UNIT THREE

OUR BORDER ENVIRONMENT UNDER STRESS

THE CHANGING FACE OF THE LANDSCAPE

LESSON OVERVIEW

In the previous unit, students looked at the growth of plant, animal, and human populations in the region. This activity prompts students to consider the effects that population change over time has on the landscape (and the overall environment). Students will study maps, satellite imagery, landscape photographs, and other provided graphic images to observe changes in the landscape over time. Several sources are used, each with "before" and "after" dated references. Student teams will be assigned image sets that they will first discuss amongst themselves, and then share with the rest of the class. After all of the images have been presented to the class, they will be displayed at designated stations. The class will then rotate to the different stations and complete a study guide about the changes depicted in the graphics. An extension of this activity encourages students to investigate the existence of old family photographs of the area, and to return to and photograph those sites for comparison. Students may also choose to set up photo stations to document change in their own community.

TEACHER PREPARATION

✓ Be sure each student has a copy of the following: Student Activity – Study Guide: *Analyzing Environmental Change*.
✓ Review the Student Activity – Study Guide: *Analyzing Environmental Change* and the "Changing Face of the Landscape Image Sets." Study the transparency master labeled "Teacher's Example". Consider the changes depicted in the teacher example and prepare to discuss it following the questions in Part One of the *Student Activity – Study Guide.*
✓ Have ready, the seven sets of images to pass out to student teams.
✓ Select the location(s) around the room which will be the station(s) designated for students to place their matching images.
✓ Have ready, an overhead projector.

TEACHING STRATEGY

1. Review. Review briefly the previous activity in which students graphed human population growth in our region. Ask students to consider the environmental changes that might occur due to the great increases in human populations as illustrated in that activity.
2. Present Example.Use the "Teacher Example Page" graphic images to demonstrate how images may be used to show environmental change. Present the images as you would have the student teams present theirs, by following the questions from Part One of the Student Activity – Study Guide. As the images are not large, you may have to pass the page around for everyone to see. Discuss the factors that might have caused the changes to the landscape. Ask students how the changes we can see might affect other biotic factors of the environment that we can't see (such as animals that live there). How might environmental changes affect the interactions in an ecosystem? What

LESSON OBJECTIVES

Upon completion of this activity, students will be able to:

- list and describe at least three ways that the landscape may be altered due to human activities.
- read and analyze landscape photographs and satellite images and make predictions about the conditions of the environment depicted.
- discuss the effects of human population on the "observed" environment
- describe two tools which may be used to graphically show environmental change.

TIME NEEDED

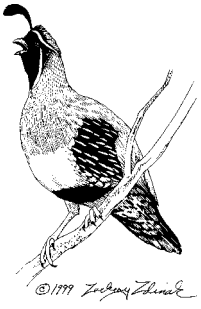
This activity may be completed in one class period.

MATERIALS NEEDED

- Overhead projector
- Overhead transparency master: Landscape Image Set - Teacher's Example
- Changing Face of the Landscape Image Sets (included with this Juntos curriculum)
- Student Activity – Study Guide: *Analyzing Environmental Change*

CURRICULUM TIES

Arizona: 1SC-P1; 3SC-P1; 3SC-D1
O'odham: A.2.8; A.4.3; A.6.3; A.7.3; A.11



other kind of information (not visible in the photograph) is helpful in interpreting the images?

3. Introduce activity. Explain that this activity is going to give each team the opportunity to study actual graphic images that depict local environmental change in one form or another. It will be up to them to review and analyze the images (the previous example should have given them an idea how to compare and analyze their images).
4. Create teams. Divide the class into seven teams. Give each team a set of paired images. (Some image sets have more images than others).
5. Review study guides. Refer students to their Student Activity – Study Guide: *Analyzing Environmental Change*. Explain that the first part of the study guide is for them to answer as a team in reference to their team's assigned images. The second part is to be completed after all the images have been presented and are set up around the room for students to analyze.
6. Student analysis of images. Give student teams time to study and analyze their images. Part One of their study guides will serve to prepare them for their class presentation.
7. Student presentations. When students are ready, have each team come up to the front of the class and present their paired images. As part of their presentation, they should explain their answers to the questions in Part One of their study guide. Each team should place their images in a pre-designated location for other students to view.
8. Complete Part 2. After all teams have presented and displayed their images; give students time to complete Part Two of their study guides. They will need to refer to all the images to answer the questions so should be allowed to go and study the other images while completing Part Two.
9. Wrap up. Regroup and review Part Two as a class. Conduct a wrap-up discussion on the activity. Ask students to consider environmental changes they have seen within the time span of their own lives. Remind students to consider that there is environmental change we can see in photographs and other graphic images but there are also environmental changes we cannot see.

EXTENSIONS

Personal landscapes. Have students seek out old photographs of their home, neighborhood, etc. from their family or community. Instruct them to try to find the location where the photograph was taken. Next, have the students attempt to take another photograph in the exact same location. Have students compare their photographs.

Photo stations. Have students locate an area where they could set up a photo station. A photo station is one they can return to time after time to take similar photographs. The site may be chosen based on its location overlooking an area slated for development, its vegetation, nearness to a streambed, etc. Students could take several photographs over time for comparison but may also consider creating a file on their photo station with directions and photographs so that future students could continue the study.

SUGGESTIONS FOR ASSESSMENT

- Assign students paired graphic images different from the first pair they received. Without providing prompting questions (such as provided in the students activity sheet), have them describe (either orally or written) the images and the changes depicted in them. Assessment would be based on the level of detail described by the student.
- Instruct students to write an essay describing ways that graphic images may be used to depict environmental change.

ADDITIONAL RESOURCES AND REFERENCES

http://earthrise.earthkam.ucsd.edu/earthrise/main.html
Earthrise provides a database of photos of the Earth from space.

http://terraserver.microsoft.com/default.asp
Terraserver provides aerial photographs primarily of the U.S. but does include other parts of the planet.

http://edcwww.cr.usgs.gov/earthshots/slow/tableofcontents
Earthshots provides a series of satellite images that depict environmental change at select locations around the globe. Images span up to twenty years apart providing "before" and "after" shots of the same locations.

http://biology.usgs.gov/luhna/contents.html
This site offers numerous research articles on "Landscape Use History of North America" (LUHNA). Of particular interest is the article: Landscape Changes in the Southwestern United States: Techniques, Long-term Data Sets, and Trends by Craig D. Allen, Julio L. Betancourt, and Thomas W. Swetnam, from which several of the photograph for this activity were taken.

These images show what heavy flooding can do to a river channel. Depicted is the Santa Cruz River in Tucson, Arizona. In the top image is Silver Lake, an impoundment created on the river to power the waterwheels of local flour mills and to provide irrigation water for agricultural lands. The bottom image depicts the channel as it is today. Deep arroyo cutting, initiated by heavy flooding in 1890, ultimately destroyed the lake. It is also important to note, the Silver Lake was man-made and the river likely looked very different before the lake was created.

Silver Lake, Santa Cruz River, Tucson, Arizona 1891

Santa cruz River (former site of Silver Lake), Tucson, Arizona 1982

(Photos: 1891, unknown; 1982, R. M. Turner and J. L. Betancourt).

ANALYZING ENVIRONMENTAL CHANGE

Part One

Directions: Answer the questions in Part 1, below, in reference to your team's assigned images. Use your answers as a guide when you present your images to the class.

Check the box that indicates the type of graphic your team was assigned:

☐ photograph ☐ map ☐ satellite imagery

1. a. Where is the area depicted in the images? b. How close is this to your community (approximate distance and direction)? _____

_____

2. Describe what is depicted in your paired images (e.g., is it a river, rangeland, population, town, etc.?) _____

_____

_____

3. What are the dates on the two images and how much time has passed between the first and the second images?

_____

4. Describe (in some detail) the environmental changes that have occurred as depicted in the images (e.g., more or less trees or other vegetation, development, agricultural changes, erosion, etc.) _____

_____

_____

_____

5. What is the likely cause of the changes noted between the two images? Suggest several possible reasons for the changes. _____

_____

_____

6. What role (if any) did humans have in the environmental changes noted? _____

_____

_____

_____

_____

Part Two

Directions: Answer the questions in Part 2, below, in reference to all of the class's images.

7. Describe the set of illustrations you feel depicts the most visually obvious changes. Explain why. _____

_____

_____

_____

_____

8. Which images are likely the result of human population increases? _____

_____

_____

9. Which images are likely caused by natural environmental changes over time? _____

_____

_____

10. List and describe 3 ways human activities can affect the environment. _____

_____

_____

_____

_____

11. What other kind of information (not visible in the images) is helpful in interpreting the images? _____

_____

_____

_____

12. Which pair of images do you like the best and why? _____

_____

_____

_____

_____

13. What is the point of this exercise? _____

_____

_____

_____

14. What are the three types of graphic images used in this lesson to demonstrate environmental change? _____

_____

_____

_____

MEASURING AND MONITORING ENVIRONMENTAL CHANGE

LESSON OVERVIEW

While the previous activity looked at ways to visually document changes to the landscape, this lesson overviews other strategies used by scientists to measure and monitor environmental change. Students will rotate through several stations to conduct investigations on air, water, soil, and biological diversity. Each station will be set up with materials, tools, and instructions for gathering information on a specific resource. (At the air station, students learn about the different pollutants found in our air. They then make and set up devices to monitor the particulate matter in the air around their school (and community if desired). At the water station, students learn about and test the quality of several water samples brought into the class from different sources. At the soil station, students investigate the qualities of soil samples from different areas in their community and compare the permeability of different soils. At the biological diversity station (located outside), students measure the diversity and abundance of plant species in designated study plots.) This activity exposes students to a variety of environmental measuring and monitoring techniques. Because of the scope of the investigations, is intended to take more than one class period and may even lead to the class conducting long-term monitoring projects.

TEACHER PREPARATION

- ✓ Be sure each student has a copy of all the necessary data sheets as noted in the "Materials Needed" list for each lab.
- ✓ Carefully review the background information and procedures for each of the four environmental lab stations and assign this as backgroundreading for your students.
- ✓ Prepare photocopies of all student data sheets (directions are on each lab write-up).
- ✓ Prepare photocopies of all lab station procedure and information "posters" (directions are on each lab write-up).
- ✓ Choose locations for the lab set-ups in your classroom (or laboratory) and locate appropriate sites on campus for the biodiversity study.
- ✓ Set up the lab stations as described in "Lab Preparations" for each station. The biological diversity station is conducted outdoors and set up by students so for this station, it is only necessary to have the site designated and prepare the materials needed.

TEACHING STRATEGY

There are a variety of ways for all students to conduct all the labs. We encourage you to do what works best for you and your class. However, we suggest the following strategy:

1. Have all lab stations set up with all the materials necessary.
2. When the class begins, introduce the lab and go over the procedures at each lab station. Review the background information for each station. If the background reading was not assigned as the previous day's homework, you may choose to have a student read the background information from each station. Answer questions the student may have about the stations.

LESSON OBJECTIVES

Upon completion of this activity, students will be able to:

- analyze environmental data collected from various sources and discuss the variation in results from different samples.
- name and discuss the implications of at least two "criterion" air pollutants
- describe how and why pH, hardness, chlorine, and nitrate are measured in water samples.
- define and discuss the difference between diversity and abundance
- define how soil characteristics may affect permeability of soil.
- discuss the importance of measuring and monitoring environmental change.

TIME NEEDED

Three class periods are needed for all students to go through all stations following our suggested teaching strategy (one period for review and discussion of the labs with time to complete one station; one period with time for students to conduct two stations, and one period for completion of the last station and analysis and discussion of data).

MATERIALS NEEDED

- Refer to each of the lab station procedures for the materials needed for that station.

CURRICULUM TIES

Arizona: 1SC-P1; 1SC-P2; 4SC-P6; 5SC-P1; 6SC-P5; 6SC-P6
O'odham: A.5.3; A.6.3

3. Divide the class into four teams. Assign each team a different beginning station and indicate how students will rotate through the different stations.
4. On the first lab day, students will likely have time for only one lab station following the introduction and discussion. On the second lab day, give teams half the class period to work on their second lab station before rotating to their third station. If they complete the stations before the allotted time, instruct them to answer the "Discussion Questions" on their data sheets for each lab. On the third lab day have students complete their final lab station then re-group in the classroom.
5. Use the remaining time of the third day to review data, answer questions, and analyze and discuss results. Refer to the "Discussion Questions" on the data sheets as a guide for the class discussion.
6. Discussion. It is important for students to understand the implications of measuring and monitoring the environment. Have them consider other environmental parameters that are monitored such as climate, water quantity, or perhaps population growth of certain species (including humans). Ask students the following questions:

    Why is it important to measure and monitor environmental conditions?

    What are some examples of implications of environmental changes? (e.g. What happens if soil becomes impermeable?, Why might the plant diversity of an area suddenly decline? etc.)

    For these labs, we only measure a portion or sample of the entire resource. Does the data gathered from samples reflect what's happening in the real world? Why or why not?

EXTENSIONS

Conduct a long-term environmental study. Have students repeat this lab (or parts of it) throughout the remainder of the school year. They could gather data once each month and look at changes over time.

Conduct further investigations. Have students conduct further investigations about one of the environmental parameters tested in this activity. They might find out if and how that parameter is measured and monitored in their community.

Invite a guest speaker. Using contacts from "The Student Guide to Environmental Opportunities and Resources," have students invite a local expert to come speak to the class about the measurement and monitoring of water, air, land, or biological diversity (or other environmental parameters) in the region.

COMPARING THE PERMEABILITY OF DIFFERENT SOIL SAMPLES

LAB OVERVIEW

Note: This lab is adapted with Permission from Arizona Project Wet's Nonpoint Source Pollution curriculum. In this lab students will study the permeability of different soils collected from around their community. Students will measure how much water moves through different soil samples within a specific amount of time. They will then calculate the rate at which the water passed through the soil and rank the relative permeability of the different samples. Through discussion, the class will relate how permeability of soil affects groundwater movement. They will also gain an understanding of how groundwater is vulnerable to contaminants in the soil.

LAB PREPARATION

1. Read all of the Background Information materials.
2. Review the Student Activity Lab Procedures and Data Sheet to become familiar with the lab.
3. Gather the materials needed listed below (including making any photocopies).
4. Decide in advance where you will allow (or not allow) students to collect their soil samples. See "Suggestions" below.
5. Coordinate the lab station rotation schedule with other "Measuring and Monitoring Environmental Change" Lab Stations. Assign the background reading (Background Information Fact Sheet – *Soil Characteristics*) in conjunction with other readings from the different lab stations.
6. Instruct student teams to collect soil samples from different areas around the community. For the lab, each team should have at least one soil sample, though more may be collected if desired. See "Suggestions" below. Each sample should be bagged and labeled. Every sample should be given a number or name. Each label should have the date, sample number, location where the soil was collected, and the name of the collector or team for whom the sample was collected. The collector should also write a brief description of the collection site, which includes a description of the vegetation in the area and what it was like to dig in that soil. Students will be entering this information on their data sheets. Each soil sample should be dried by keeping the collecting bags open overnight or longer if the soil is very wet.
7. Prepare the styrofoam cups for the lab by poking 15 small holes in the bottom of the cups with a nail or other sharp object. Be sure that the number, size, and location of the holes in each cup is the same (so as not to skew results).
8. Set up the Soil Permeability Station as follows:

- Designate a workstation with a table that will accommodate one team of students (about a fourth of your class).
- At the station, place the styrofoam cups, beakers, gauze, tape, stopwatch, ring stand (or equivalent), petri dishes, and hands lenses or stereoscope. Hang (or tape to the tabletop) the Student Activity Lab Procedure – *Comparing the Permeability of Different Soil Samples.*

9. Prepare a data table on the chalkboard in the front of the room using the data table on the student data sheet as a guide.

MATERIALS NEEDED

- Background Information Fact Sheet- *Soil Characteristics* (assign this to all students to read before the lab—or may be read aloud in class)
- Student Activity Lab Procedures – *Comparing the Permeability of Different Soil Samples* (one copy to be posted at the Lab Station)
- Student Activity Data Sheet- *Comparing the Permeability of Different Soil Samples* (one per student)
- soil samples (two liters each) (each team should have at least one soil sample)
- bags for collecting soil sample
- stop watch or clock with a second hand
- styrofoam cups (with holes in the bottom – see "Lab Preparation" above)
- gauze
- rubber bands or duct tape (to secure the gauze to the cup)

- ring stand or other device to hold the cups steady without obscuring the holes in the bottom of the cup
- 100 ml beaker or other graduated container (a cup with a line depicting 100ml would work)
- 100 ml beaker or other graduated container (this one needs to be clearly graduated (marked) with at least 10 ml intervals)
- petri dish (or similar container)
- hand lens or stereoscope (desirable but optional)

ACTIVITY PROCEDURE

Note: Students should already have collected and dried their soil samples before the lab begins. They should arrive to this station with their soil samples. Students should also have read the Background Information Fact Sheet - *Soil Characteristics*.

1. Distribute data sheet and review lab procedures. As students arrive to this lab, be sure they have their copy of the Student Activity Data Sheet – *Comparing the Permeability of Different Soil Samples*. Refer to and review the *Student Activity Lab Procedures* for conducting the lab answer any questions.
2. Examine and record the physical characteristics of the soil. Have students follow the questions on their data sheet to examine a sample of their soil and describe it according to the following characteristics: organic matter, color, texture, smell, and degree of sorted ness.
3. Prepare cup for testing. Have students place a piece of gauze over the bottom of a styrofoam cup with holes in it. The cup should be placed cup in the ring stand and an empty beaker placed under it. (If a ring stand is unavailable, another device may be used as long as it doesn't obstruct the holes. It is preferable that the cup is not hand held as different individuals may tend to shake the cup and influence the flow.)
4. Place soil in cup. Students should then put 100 cc of the soil sample in the cup. Students should next measure 100 ml of water into the graduated cylinder and get ready to pour it into the cup.
5. Conduct the test. When the clock is on the minute (or the stop watch is started), students should pour the water into the cup. After four minutes, students should remove the beaker used to collect water running out the bottom of the cup. (If water is still dripping, they may need to place another container in its place, but any additional water should be discarded.)
6. Measure and record. Using the beaker or other graduated container, have students measure the amount of water collected in the beaker and record the amount in their data tables.
7. Calculate rate of water movement. Students should calculate the rate at which the water passed through the soil sample. They will need to divide the amount of water collected, by the time it took the water to drain through the soil (4 minutes). Remind them to label their units and record the information on their data table.
8. Complete data tables. Have students write their results on the data table on the board. Once every team has conducted the experiment and recorded their results on the board, they should copy the information onto the data table on their data sheets. Each student should rank the relative permeability of the soil samples.
9. Wrap up. As part of the class discussion about this lab, students should be asked to review the questions on their data sheets. Emphasis should be placed on why soil permeability is an important environmental factor to measure.

SUGGESTIONS

It might be very interesting to have students bring in soil samples from different areas of the community to provide a diversity of results. Encourage students to seek out a variety of areas to collect their samples such as washes or stream banks, vegetated areas, recently disturbed areas, gardens or agricultural fields, etc.

EXTENSIONS

Obtain a copy of "Arizona WET - Nonpoint Source Water Pollution Curriculum" and conduct additional activities on the study of soil and groundwater.

Contact: Arizona WET

Kerry Schwartz, Project WET Coordinator
Water Resources Research Center
The University of Arizona
350 N. Campbell Ave., Tucson, Arizona 85719 Phone: (520) 792-9591 ext. 22 Fax (520) 795-8518

SOIL CHARACTERISTICS

The porosity and permeability of the soil determines how well water will drain or be absorbed. Porosity describes how much of the soil is made up of voids or open spaces. Permeability is the ability for water to move through the soil. For example, the permeability of gravel is high because the spaces between each particle are large, allowing water to move rapidly through it. However, gravel has a low porosity. The number of empty spaces between each particle is small even though the spaces themselves are large. Unlike gravel, clay has a high porosity since it is made up of many tiny particles with many tiny empty spaces between each particle. However, the permeability of clay is low because the spaces between clay particles are small and are not well connected, making it difficult for water to flow through it. Soil is said to be well sorted if all of the particles are about the same size. Soil that is poorly sorted is made up of a mixture of different sized particles.

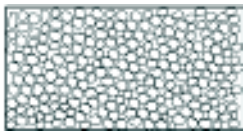
Poorly - Sorted

Small Voids
(Low - Medium Porosity)
(Low - Medium Permeability)

Well - Sorted

Few Low, Large Voids
(High Porosity)
(High Permeability)

Well - Sorted



Many, Very Small Voids
(High Porosity)
(Very Low Permeability)

Organic means “coming from life.” Organic matter in the soil comes from living organisms, and includes animal manure, plant parts, and dead animal and insect remains. Organic matter tends to aerate (cause more air spaces to form between soil grains) the soil, which can affect the soil’s porosity and permeability. Water is more easily absorbed in soil containing much organic matter than in soil with little organic matter Organic matter also adds important nutrients to soil, which plants need for healthy growth.

As water moves through soil, it dissolves some of the soil’s nutrients and minerals. If pollutants are on or in the soil, they may be dissolved and carried through the soil to the groundwater. These pollutants can end up in an aquifer and may eventually be pumped to the surface along with the drinking water. Pollutants can be carried by surface runoff into washes and streams. Can you see why it is important not to dump materials onto the ground? Pollutants such as motor oil or paint can move through the soil with the water and eventually end up in your drinking water.

Soil Permeability Station
Lab Procedures
(To be posted at the Lab Station)

COMPARING THE PERMEABILITY OF DIFFERENT SOIL SAMPLES

1. Prepare an observation sample. Place a small sample of your soil into the petri dish to study its qualities and characteristics.

2. Examine and record the physical characteristics of the soil. Following the questions on your data sheet, examine your soil sample and describe it according to the following characteristics: organic matter, color, texture, smell, and degree of sorted ness. Write your descriptions of each characteristic on your data sheet.

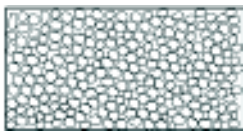
Poorly - Sorted

Small Voids
(Low - Medium Porosity)
(Low - Medium Permeability)

Well - Sorted

Few Low, Large Voids
(High Porosity)
(High Permeability)

Well - Sorted



Many, Very Small Voids
(High Porosity)
(Very Low Permeability)

3. Prepare soil sample for testing. Select a styrofoam cup with holes in it and place a piece of gauze over the bottom of it. Use either rubber bands or tape to secure the gauze in place. Put the cup in the ring stand (or equivalent) and place an empty beaker under it. (If a ring stand is unavailable, another device may be used as long as it doesn't obstruct the holes. It is preferable that the cup is not hand held as different individuals may tend to shake the cup and influence the flow.)

4. Put 100 cc of your soil sample in the cup.

5. Measure 100 ml of water into the graduated cylinder and get ready to pour it into the cup.

6. When the clock is on the minute (or the stop watch is started), pour the water into the cup.

7. After four minutes, remove the beaker used to collect water running out the bottom of the cup. (If water is still dripping, you may need to place another container in its place, but discard any additional water.)

8. Measure the amount of water collected in the beaker and record this on your data sheet.

9. Calculate the rate at which the water passed through the soil sample. To do this, you need to divide the amount of water collected, by the time it took the water to drain through the soil (4 minutes). Be sure to label your units. Record this on your data sheet.

10. Write all your results on the data table on your data sheet and then on the board.

11. Once every team has conducted the experiment and recorded their results on the board, copy the information onto your data table. Rank the relative permeability of the soil samples.

12. Complete all the discussion questions on your data sheet.

SOIL PERMEABILITY

Name _____

Part 1

Directions: Complete the following below. You may work as a team but each student should examine his or her own sample and complete their own data sheet. When finished, conduct your permeability test as a team and record your results on the following page.

1. Sample number or name: _____

2. Location where soil was collected. *Where did you obtain your soil sample?* _____
_____

3. Site Description. *Describe the area where your soil was collected. Include a description of how difficult it was to dig in this soil.*_____
_____
_____

4. Physical characteristics of the soil.
Organic matter – *Is there any organic matter in your sample?* _____
Describe it: _____
_____
_____
From where might this organic matter have come? _____
_____

5. Describe the following characteristics:
Color: _____
Smell: _____
Texture: _____
When you squeeze the soil, does it clump or is it loose? _____

6. Degree of sortedness – *Examine your sample with a hand lens or stereoscope. Draw and describe what you see. In your description, explain if the soil is well sorted or poorly sorted.*

SOIL TYPE			PERMEABILITY		
Sample number or name	Collection Site	Description	Amount of water Collected After 4 Minutes	Rate of Drainage (ml/min)	Relative Rank

MEASURING AND MONITORING BIODIVERSITY

LAB OVERVIEW

The focus of this station is the measuring and monitoring of biological diversity. After reading about biological diversity, teams of students will create biodiversity study plots. They will then measure the diversity and abundance of the plants and animals located within their study plot.

LAB PREPARATION

1. Review the Background Information Fact Sheet - *Biodiversity* and assign this as background.
2. Review the Student Activity Lab Procedures and Data Sheet to become familiar with the lab.
3. Gather the materials needed listed below (including making any photocopies).
4. Decide in advance where you will allow (or not allow) students to place their study plots (at specific locations around the school, neighborhood, community, etc.). See "Suggestions" below.
5. Coordinate the lab station rotation schedule with other *Measuring and Monitoring Environmental Change* Lab Stations. Assign the background reading (Background Information Fact Sheet – *Biodiversity*) in conjunction with other readings from the different Lab Stations.

MATERIALS NEEDED

- Background Information Fact Sheet – *Biodiversity* .
- Student Activity Lab Procedures - *Measuring and Monitoring Biodiversity* (one copy to be posted at Lab Station)
- Student Activity Data Sheet – *Biodiversity* (one per student)
- Tape measure
- String
- 4 poles (sturdy sticks will do)
- Thermometer
- A field guide to the plants and animals (if none is available, students may assign names to the plants and animals they find – there should be some class consistency to the names chosen)

ACTIVITY PROCEDURE

1. Review lab procedures. When a team arrives at this lab station, be sure each student has their copy of the Student Activity Data Sheet – *Measuring Biodiversity*. Review the Student Activity Lab Procedures – *Biodiversity Station* and be sure students understand how to set up their plots. Review the data they need to collect and answer any questions.
2. Site selection and set-up. After explaining the locations where they may and may not work, have each team pick a study site. Instruct each team to mark out an area to form a square plot measuring 5m x 5m. Student should mark their plots with tape (see illustration).
3. Conduct biodiversity counts. Ask your students to count the number of *different kinds* of plant species in their quadrant (diversity). Also have them count the total number of plants of each species (relative abundance). Have students count the total number of plants (abundance) [They may also figure this out by adding the totals of each species]. Ask students to also search for and count animals (especially arthropods). (Note: if students don't know the name of each species, have them assign each type of plant and/or animal a name or number to identify it).
4. Record data. Ask students to record their plant and animal count data on their data sheets. Instruct them to also complete all other information on the data sheets.
5. Compare. Collect and merge your students' data into a single table on the chalkboard. (When coming up with the class' total biodiversity figures make sure that you only count each species once.)
6. Discussion and conclusion. Invite student teams to present their findings and theories to the class. Review with your

students the discussion questions

SUGGESTIONS

Before students begin setting up their study plots, you may want to set parameters for where they may conduct their outdoor studies. This may be limited to the school grounds if necessary. The range of sites can be as structured or flexible as you like. Additionally, you may want to consider choosing a diversity of sites (in which the abiotic and biotic conditions differ) so that each team gathers somewhat different data.

EXTENSIONS

1. Have students design their own field guide to the plants (and animals) found in their study areas. They should include illustrations.
2. Students can use the data collected and the class discussion to draw a map of their quadrants. Have them include plants, soil, water, man made features, and a key.
3. Ask students to imagine they are an ant or other tiny insect living in a desert field and to write a story about their life and environment.
4. Consider making your study plots permanent and conduct biodiversity counts there at specific intervals throughout the year (and into future years if possible).

BIODIVERSITY

Biological diversity is the variety of life. It includes genetic diversity, species diversity, and diversity of communities and ecosystems. Scientists generally shorten the term biological (living) diversity (variety) to biodiversity. To understand biodiversity, it is helpful to look at the variety of life at each level: genetic, species, community, and ecosystem diversity.

To understand genetic diversity, consider the variations that exist between individual members of the same species. Humans can be tall or short, and have a variety of skin, hair and eye colors. Other types of animals and plants also exhibit differences between individuals of a single species. Genetic diversity may be noticeable, such as eye color in humans or it may be visually undetectable, such as blood type or susceptibility to certain diseases. Some variations between individuals of a species may be caused by environmental conditions; such variation should not be confused with genetic diversity, which is based on different combinations of genes received from parents of a particular individual.

Species diversity refers to the variety of all existing plants and animals. Spiders, jackrabbits, fungi, ants, sunflowers, coyotes, grasses, lizards, ducks, trees, woodpeckers, deer, ferns, hawks, and skunks all contribute to biodiversity. It is estimated that there are approximately 15 million species of living things on Earth. Species diversity varies form place to place depending on a variety of environmental factors. For example, an area of tropical rainforest has more different kinds of plants and animals than an equal size area of temperate, deciduous woodland. Also, it is important to distinguish between diversity and abundance. Diversity refers to the numbers of different kinds of species (or variety) while abundance indicates total numbers or quantity regardless of species. Although there may be a lot of animals or plants in an area, they may all be of only a few different kinds. For example, there may be an abundance of birds in your schoolyard, but if you look closely you may find that they are probably almost all sparrows or pigeons. This lack of variety signifies low species diversity.

A community is a group of interacting species that occupies a particular place. Communities are often defined by the type of existing vegetation, and most abundant or obvious plants. When one considers the soil, climate, water, and other non-living (abiotic) factors along with the plants and animals making up the community, the unit is called an ecosystem. Ecosystems may be as large as the entire planet, with all of its constituent communities, or as small as a decaying log. While the scale may differ, an ecosystem is an association of living and non-living things interacting together in a dynamic and complex system.

Why is biological diversity so important? Our existence in intricately tied to the health and existence of other life forms. All of our food and most of the products we use for clothing and shelter come from living things. Originally, almost all of our medicines came from plants or animals and we still get about 50% from plants. New medicines are still being discovered in "nature's pharmacy." In addition to useful products such as food and medicine, plats and animals play key roles in the numerous regulatory cycles that cleanse our air and water. Climate is partially regulated by large tracts of vegetation, which also help balance atmospheric carbon dioxide by serving as a reservoir of carbon. These ecosystem services are vital to the continuation of all life on the planet. In the words of the Wilderness Society: "*Living things maintain the habitability of the Earth. Without the services performed by diverse, intact communities of the plants and animals, and microorganisms, we would be starving, baking, gasping for breath and drowning in our wastes*."

Unfortunately, loss of biological diversity on this planet is occurring at startling rates. Loss of habitat, pollution, commercial exploitation, predator eradication, climate change (global warming), ozone depletion, invasion of exotic species, and numerous other factors all contribute to the loss of species, community, and ecosystem diversity. Genetic diversity decreases when any population size is reduced. It is projected that by the year 2020, as many as 40,000 species may go extinct each year. It is also estimated that 1000 acres of rainforest are lost per hour and that 32,000 square miles of ounce useful agricultural land are lost to desertification each week.

What are humans losing with this decline in the variety of life? Besides losing the ecosystem services mentioned above, we would also likely feel loneliness and boredom if we reduced life to a few selected species. Many people find excitement as well as solace in nature. Hiking, bird watching, camping, snorkeling, and touring are activities in which many people participate. Many people consider contact with nature to be a basic human need. Also, although we speak of the importance of preserving biological diversity because of its usefulness to humans, it may be appropriate to consider the existence of plants, animals, and natural communities in their own right. Does a thing have the right to exist only because of its use to humankind? Or does it have an inherent right to exist simple because it "is?"

Scientists' worldwide are studying biological diversity and considering strategies for conservation of biodiversity on a global scale. One strategy has been to identify areas where biological diversity is greatest and focus conservation efforts on those areas. These areas are usually identified after exhaustive field studies in which biologists estimate the diversity and abundance of an area's plants and animals using accepted field techniques. These same techniques may be conducted on a small scale at local field sites. This biodiversity lab exercise will utilize one of these techniques.

Biodiversity Station
Lab Procedures
(To be posted at Lab Station)

MEASURING AND MONITORING BIODIVERSITY

Instructions: At this station, you will conduct your own terrestrial biodiversity study to calculate the number of plant species at a local field site. The technique used is similar to the kind biologists use when studying the biological diversity of an area. Each team will select a site at which to set up a study plot (called a "quadrant") following the directions below. You will then gather data on the diversity and abundance of plants and animals (primarily insects) in your study plot. This is your chance to find out how many different types of plants and animals live in your own schoolyard or other small area of nearby desert!

1. After your teacher has explained the locations where you may and may not work, choose an appropriate location to set up your study plot. It may be good to coordinate study site selection with other teams in order to gather a diversity of data.

2. At your study site, use the tape measure to measure out an area to form a square plot measuring 5 meters by 5 meters. Mark the corners of your plot with the stakes and mark the perimeter of your plot with string (see illustration).

3. Measure the temperature of your plot above ground at the ground level. Record your data. Also on your data sheet, describe the soil and meteorological conditions of your site.

4. Conduct your biodiversity counts. Count the number of *different kinds* of plant species in your quadrant. Even if you do not know the names of the plants, take note of all the different kinds and if needed, assign them names or numbers for future reference. The measure of the number of different species is call species diversity. Count the total number of plants of each species. This will give you the relative abundance of that species. Count the total number of all plants. This will give a measure of the abundance of all plants. [You can also figure this out by adding the totals of each species].

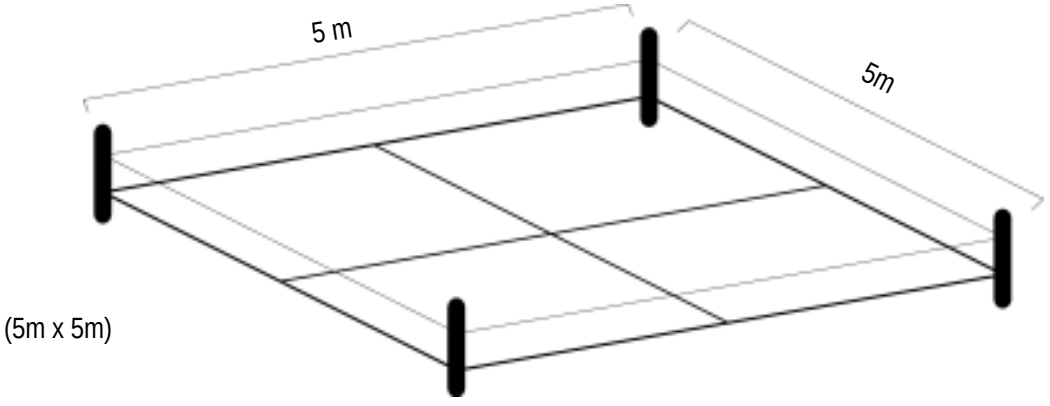
5. As you identify each different species, enter the information on your data sheet. Also enter all your counts on the data sheet in the appropriate location.

6. While you are investigating your plot, also search for and count all animals you encounter (these will likely be arthropods). Again, if you don't know the name of each species, assign each animal a name or number to identify it.

7. Record all your data on your data sheet. Be sure to complete all other information on the data sheet.

8. Return to the classroom and enter your data with the class's tabulation of data.

9. Once all teams have completed their study plots and compiled their data on the class's data table, answer the discussion questions on your data sheets.



(5m x 5m)

BIODIVERSITY

Your name: _____

Team member's names: _____

Quadrant name or number: _____ Class: _____ Date: _____

Site description: _____

_____

_____

List the following abiotic information for your quadrant:

Temperature (above ground): _____

Temperature (ground level): _____

Soil description (color, moisture, texture, etc.): _____

_____

Meteorological conditions (rain, cloud cover, wind direction, etc.): _____

_____

Follow the directions from the Lab Procedures and complete the tables below.

PLANT BIODIVERSITY TABLE

Species name (common / latin) or assigned name	Number of individuals of this species	Relative Abundance (# of individuals of this plant / total # of plants)

ARTHROPOD BIODIVERSITY TABLE

Species name (common / latin)	Number of individuals of this species	Relative Abundance (# of individuals of this insect / total # of insects)

Additional animal sightings: _____

_____

Discussion questions:

1. Were there noticeable temperature differences between your class's plots and if so, how does temperature appear to affect the biodiversity of your study plots? _____

_____

2. Which quadrant contained the most plant individuals? _____
3. Which quadrant contained the least plant individuals? _____
4. Which quadrant contained the most plant diversity? _____
5. Which quadrant contained the least plant diversity? _____
6. What physical features of the study plots seem to influence plant abundance? _____

_____

7. What physical features of the study plots seem to influence plant diversity? _____

_____

8. What is the difference between abundance and diversity? _____

_____

9. How might your study plot change during the course of a year? _____

_____

10. How would a biologist use this kind of data to study biodiversity? _____

_____

MONITORING AIR QUALITY

LAB OVERVIEW

The focus of this station is the measuring and monitoring of air quality. After reading about the different types of pollutants in our air, students will make particulate matter (PM_{10}) "collecting" cards and place them at different locations around the school (or if desired, around the community). After several days, students will collect their cards from the various locations and analyze and compare their findings.

LAB PREPARATION

1. Read all of the Background Information materials and assign this as background reading for your students (note: the "Poster Sheet" is repeated in large print to be posted at the Lab Station).
2. Review the Student Activity Lab Procedures and Data Sheet to become familiar with the lab.
3. Gather the materials needed listed below (including making any photocopies).
4. Set up the Air Quality Monitoring Station as follows:
   - Designate a workstation with a table that will accommodate one team of students (about a fourth of your class).
   - At the station, place the index cards (or substitute), coins, scissors, clear adhesive tape and waterproof marker.
   - Hang (or tape to the tabletop) the Background Information Poster Sheet- *Monitoring the Quality of the Air We Breathe;* the Background Information Poster- *The Criteria Pollutants*; and the Student Activity - Lab Procedure - *Air Quality Monitoring Station*.
5. Decide in advance where you will allow (or not allow) students to place their monitoring cards (at locations around the school, neighborhood, community, etc.). See "Suggestions" below.
6. Coordinate the lab station rotation schedule with other "Measuring and Monitoring Environmental Change" Lab Stations. Assign background readings (Background Information Fact Sheet- *Monitoring the Quality of the Air We Breath*) in conjunction with other readings from the different Lab Stations.
7. As teams of students arrive at this station, be sure they have their copy of the Student Activity Data Sheet- *Monitoring Air Quality* (two pages). Instruct them to read the posted "Lab Procedures" and Background Information posters and follow all directions.
8. After students have finished making their monitoring cards, allow them to place the cards at their selected locations. If they will be taking the cards out to their neighborhoods or away from the school, the cards should be carefully covered with plastic, taking care not to touch the adhesive side of the tape.
9. After some days (a week is OK) have passed, have students retrieve their monitoring cards. Have them measure and compare their results using the *Particulate Scale* sheet. They should complete their Data Sheets.
10. Invite student teams to present their findings and theories to the class.

MATERIALS NEEDED

- Background Information Fact Sheet- *Monitoring the Quality of the Air We Breathe* (may also be read aloud in class)
- Background Information Poster Sheet- *Monitoring the Quality of the Air We Breathe* (one copy to be posted at the Lab Station)
- Background Information Poster- *The Criteria Pollutants* (one copy to be posted at the Lab Station)
- Student Activity Lab Procedures - *Air Quality Monitoring Station* (one copy to be posted at the Lab Station)
- Student Activity Data Sheet- *Monitoring Air Quality* (two pages) (one per student)
- *Particulate Scale* sheet (make enough copies for student reference)
- index cards, or heavy paper (3 cards per student team)
- 2 to 4 quarters for cutting the same sized circles (or substitute)
- two pairs of scissors
- one waterproof marker

- clear adhesive tape, preferably plastic packaging tape
- additional tape and stapler for securing cards
- plastic covering (or other method to protect cards), if transporting cards to a distant location

SUGGESTIONS

Before students begin their own monitoring, you may want to set parameters for where they may locate their monitoring sites. This can be limited to the school grounds, but could also include major intersections, students' homes, etc. The range of sites can be as structured or flexible as you like. Any location will have its advantages and disadvantages. Consider asking student teams to work cooperatively and place multiple cards (such as on several posts on different corners of an intersection) to reduce any effects of tampering on their experiment.

For making the monitoring cards, we recommend clear plastic packaging tape because of its width and strong adhesive surface. It is also preferable that cards be taped or stapled to a surface rather than hung with string or wire.

If students will be carrying the monitoring cards to locations away from the school, the adhesive surface of the tape must be protected during transit. This can be done with heavy plastic (such as from heavy-duty plastic bags).

MONITORING THE QUALITY OF THE AIR WE BREATHE

High levels of air pollution can be a threat to our health and our environment. Monitoring air quality can be useful in many ways.

The main reasons for monitoring air quality are:
- to find out the typical concentration or usual level of each pollutant
- to find out the highest concentration of each pollutant
- to study how different sources of pollutants affect pollution levels
- to compare the general background conditions in natural desert areas with the air quality in urban areas

Monitoring air quality can also help us understand relationships between air quality and weather, air quality and health, or air quality and population growth. It can tell us whether pollution prevention strategies have been effective.

There are different kinds of pollutants that we measure. All have a unique make-up, sources, and effects on humans and the environment. Particulate matter (PM_{10}), carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, and lead are all important pollutants that are measured. During the lab, you may refer to the poster of these "Criteria Pollutants" and study their qualities. The first pollutant, Particulate Matter (PM_{10}), is what you are going to measure during your lab activity.

Particulate pollution matters

The pollutants that often cause the most problems for us are particulate matter (PM_{10}), carbon monoxide, and ozone. PM_{10} is of concern to us because we generally only inhale these very small particles (less than 10 "microns" in diameter) into our respiratory tract. The health risks of inhaling particulates depend partly on what the particles are made of. Fine particles of dust from a construction site are different than the fine particles from a mine smelter or from car exhaust.

The health risks of particulates also relate to their size. This affects where they lodge in our bodies. Particles larger than 10 microns are usually filtered out by the body's natural defense system of hairs, cilia, and mucous. Particles between seven and 10 microns tend to end up in the nasal passages and sinuses. Smaller particles reach the throat and bronchi. The smallest particles, of one micron or less, can travel deep into the lungs. Having these tiniest of particles in the alveoli or lung sacs can create health problems because they prevent the alveoli from working properly. Also, the particles may include heavy metals or toxins that can pass from the lungs into the blood and then to other organs.

Particulate pollution harms the natural and built environment too. Particulates are a major cause of air visibility problems. When the particles come out of the air, they can soil buildings, increase corrosion of metals, and reduce agricultural yields.

Sources of particulate matter include traffic on unpaved and paved streets, motor vehicle exhaust, and earth-moving during construction, mining, and agricultural activities. The concentration of particulates in natural desert air is also a source of particulate matter.

The amount of particulate matter in the air varies with several factors. For example, particulate levels tend to vary according to seasonal rainfall patterns, decreasing with high humidity or rain. On the other hand, wind increases particulate levels. Particulate levels can also be different at different places in a city or town. They can be higher near unpaved roads, construction sites, heavily traveled paved roads, or other local sources.

Particulate matter and you

As with other pollutants, what we do as individuals can affect particulate levels. For example, if you or your family gets involved with tree planting projects, it's a good idea to get advice about the best trees to plant. Some trees produce pollen that bothers a lot of people. Although many pollen grains are larger than 10 microns, and so are not a part of PM_{10}, they are still particulates.

Vehicles are a major source of particulates. It's important to keep vehicle engines well maintained to minimize pollution. Little bits of tire rubber contribute to particulates, and cars stir up other particulates even from paved roads. Quick stops and starts should be avoided on paved as well as unpaved roads. Checking tire pressure regularly can help too, since properly inflated tires won't wear down as fast.

Every choice we make does make a difference. As individuals and families, we can have significant impacts on the quality of the air we breathe.

Air Quality Station
Background Information Poster Sheet
(To be posted at Lab Station)

MONITORING THE QUALITY OF THE AIR WE BREATHE

Air is a vital resource that is all around us. When air is polluted, our personal health and surrounding environment may be threatened. Thus it is important to monitor our air to determine its quality. Monitoring air allows us to identify the levels of specific pollutants in the air and their sources, determine the level of risk present, and develop strategies to improve our air quality. Monitoring air quality can also help us understand the relationships between air quality and weather, health, and population growth.

The main reasons for monitoring air quality are:

- to find out the typical concentration or usual level of each pollutant
- to find out the highest concentration of each pollutant
- to study how different sources of pollutants affect pollution levels
- to compare the general background conditions in natural desert areas with the air quality in urban areas

Air pollution comes in different forms (released gases, small particles, large particles) and from varied sources (automobile exhaust, wind-blown dust, trash-burning, etc.). The six designated "criteria pollutants" that tend to be of the greatest concern are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), lead (Pb), and particulate matter (PM_{10}). During the lab, look for the poster of these criteria pollutants and learn where they come from and the effects each one has on our bodies and the environment. The last pollutant listed, particulate matter (PM_{10}), is what you are going to measure for during this lab activity.

Air Quality Station
Background Information Poster (1)
(To be posted at Lab Station)

THE CRITERIA POLLUTANTS: ORIGINS AND EFFECTS

POLLUTANT	SOURCES	EFFECTS ON HUMANS	OTHER EFFECTS
Particulate Matter	■ dust stirred up by vehicles ■ motor vehicle exhaust ■ construction &earth moving ■ agriculture & mining ■ industrial plants & burning of coal for power ■ natural sources: windblown dust, forest fires, volcanoes	■ irritates nose & throat, causes breathing discomfort/difficulties ■ damages lung tissue & reduces lung function ■ lowers resistance to respiratory infection ■ aggravates existing lung & heart disease ■ increases incidence of lung diseases & cancers	■ reduces visibility ■ soils & discolors statues, buildings, painted surfaces ■ corrodes metal ■ interferes with photosynthesis, may damage crops ■ may alter climate
Carbon Monoxide (CO)	■ incomplete combustion of fossil fuels from vehicles & power plants ■ burning of wood ■ natural source: forest fires	■ reduces oxygen reaching brain, heart, body tissues ■ reduces alertness & ability to perfomr tasks ■ impairs perception & thought, slows reflexes ■ most serious for those with cardiovascular disease ■ high levels cause drowsiness, unconsciousness, death	■ at high concentrations toxic to animals
Ozone (O3)	■ a secondary pollutant formed when nitrogen oxides and hydrocarbons react in sunlight ■ natural source (of precursors): plants	■ chest pains, coughing, wheezing, labored breathing, shortness of breath, nausea ■ irritates respiratory system & sensitizes to other irritants ■ damages lung tissue, reduces lung function, even in healthy people ■ aggravates existing lung & heart diseases, allergies, asthma ■ exposure for months or years accelerates aging of the lungs	■ deteriorates rubber, paint, some building materials ■ damages fruits and seeds ■ injures crops and trees ■ affects whole ecosystem by altering wildlife habitat

Background Information Poster (2)

POLLUTANT	SOURCES	EFFECTS ON HUMANS	OTHER EFFECTS
Nitrogen dioxide (NO2)	■ combustion of fossil fuels in motor vehicles and at power plants/in industry ■ natural sources: lightning	■ irritation of the lungs, especially in people with asthma ■ lowered resistance to respiratory infections such as influenza ■ in children, frequent exposure to high levels may cause increased incidence of acute respiratory disease ■ effects of short-term exposure still unclear	■ reduces visibility ■ reacts with atmospheric moisture to form acid rain ■ deteriorates statues & buildings ■ damages natural vegetation & crop plants ■ reduces plant growth and seed production
Sulfur dioxide (SO2)	■ coal & oil burning power plants/ industries ■ oil refineries ■ natural source: volcanoes	■ at high concentrations, affects breathing ■ reduces the lung's ability to defend against disease ■ aggravates existing respiratory and cardiovascular disease ■ asthmatics and others with existing problems most suceptible ■ children and the elderly also especially susceptible	■ reduces visibility ■ reacts with atmospheric moisture to form acid rain ■ deteriorates statues & buildings ■ discolors slates, marble, mortar & limestone ■ damages & fades rubber, leather, paper, paint & some fabrics
Lead (Pb)	■ motor vehicle exhaust, especially from leaded fuel ■ metal smelting & processing factories ■ dust and flakes from old paint	■ accumulates in blood, bone & soft tissues ■ affects kidneys, liver, nervous system & blood-forming organs ■ relatively low doses - nervous system damage, lowered learning ability, blindness in chilcren ■ high exposure - seizures, behavioral disorders, mental retardation	■ can become part of the soil and affect plants & animal living in the soil ■ affects other mammals much like it does humans

Source: *Clean Air Program - Pima County Department of Environmental Quality*

Air Quality Station
Lab Procedures
(To be posted at Lab Station)

MONITORING THE QUALITY OF THE AIR WE BREATHE

Instructions: At this station, you will make air quality monitoring cards to test the levels of particulates in the air. Each person on your team will make one card following the directions below. One of your team's cards will be for an indoor control site and the others should be placed at experimental outdoor locations of your choice.

1. Obtain an index (or substitute) card and use a quarter to mark three circles on your card. Cut out the circles.

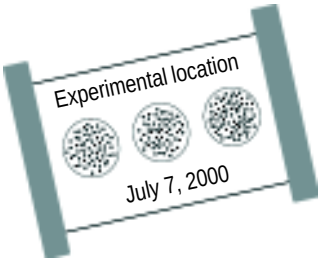
2. Label the card with your name, your team's name, the location where you will place the card, and today's date. (See example below).

3. Place clear tape over one side of the card, fully covering the holes. Be careful to not touch the sticky side of the tape. This is important because it will ensure that all the cards collect the particulate matter equally.

4. Decide as a team where you will place the different cards. (See if your teacher has specific instructions for what is allowed.) <u>One of the team's cards must be placed at a designated indoor control site</u>. Place the monitoring cards at your selected sites, taping or stapling them securely to a wall, post, tree, etc. Be sure to fill out the questions on your Student Data Sheet as you go along.

5. After five to seven days, or as long as your teacher requests, bring the cards back to class to measure and compare the particulates from each card.

6. Complete your Data Sheet.



MONITORING AIR QUALITY

Name: _____ Class _____

1. Hypothesis. Describe what you think will happen to the cards at each location. Do you think one location may yield more or less particulates than another? _____

_____

_____

Date cards set in place: _____ Date cards collected: _____

2. For each location, summarize the appearance of your cards below. Refer to the particulate scale sheet to determine the relative density of the particulates on your cards.

Experimental location 1.

Description of general area: _____

_____

_____

Specific location of monitoring card: _____

Height of card above ground: _____ Direction card is facing: _____

General description of card: _____

_____

Density of visible particulates (compare with chart): _____

Particulates identified, if any: _____

Other observations: _____

_____

Experimental location 2.

Description of general area: _____

_____

_____

Specific location of monitoring card: _____

Height of card above ground: _____ Direction card is facing: _____

General description of card: _____

_____

Density of visible particulates (compare with chart): _____

Particulates identified, if any: _____

Other observations: _____

_____

Control (indoor) location.

Description of general area: _____

_____

_____

Specific location of monitoring card: _____

Height of card above ground: _____ Direction card is facing: _____

General description of card: _____

_____

Density of visible particulates (compare with chart): _____

Particulates identified, if any: _____

Other observations: _____

_____

3. At which location were the most particulates collected? _____

At which location were the least particulates collected? _____

4. Discussion Questions. Answer the questions below based on your observations.

A) Did the results support or refute your hypothesis? Explain why or why not.

_____

_____

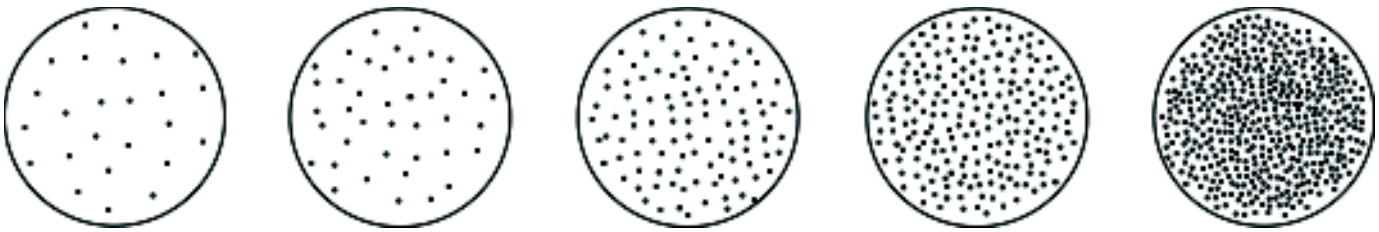
_____

B) Explain how any influences from human activities, weather, and other factors may have affected your results.

_____

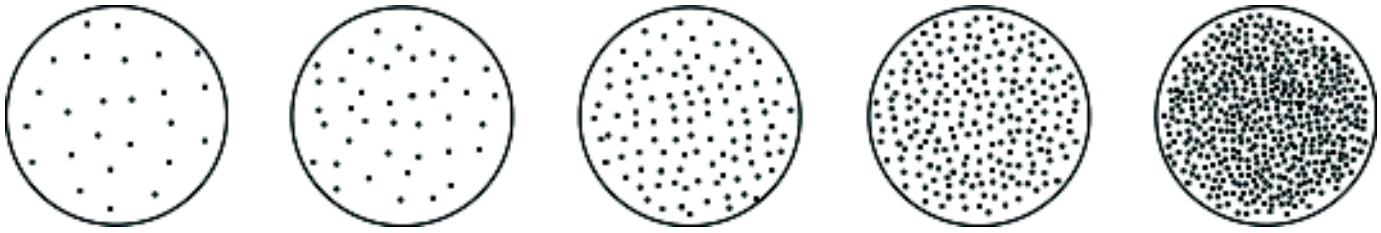
_____

_____

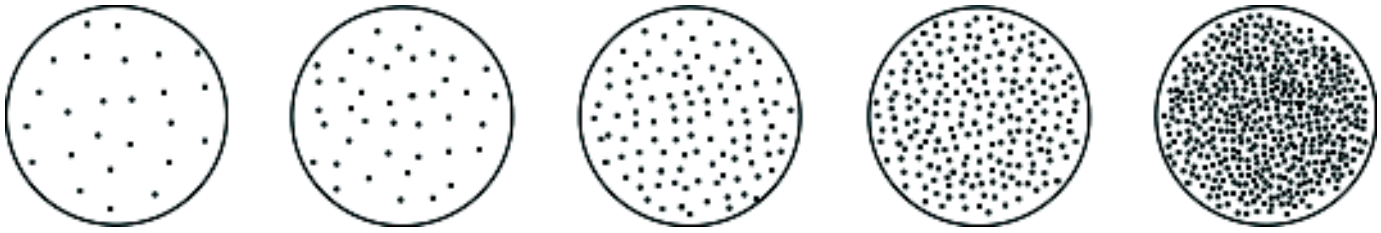


Density of Visible Particulate Matter on Monitoring Cards

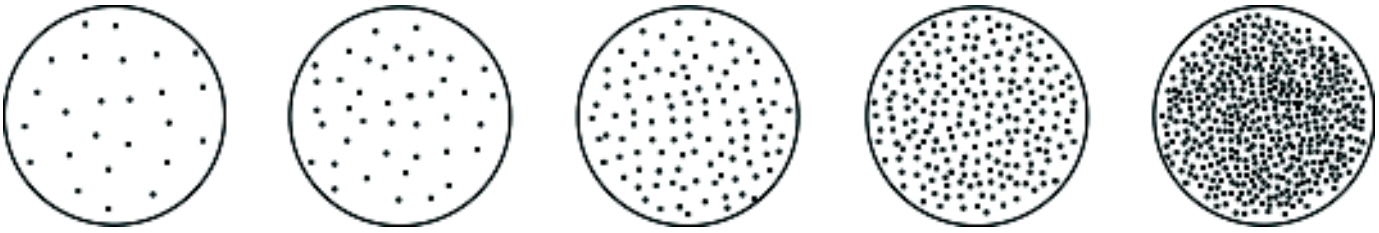
Air Quality Station
Particulate Scale Sheet



Density of Visible Particulate Matter on Monitoring Cards



Density of Visible Particulate Matter on Monitoring Cards



Density of Visible Particulate Matter on Monitoring Cards

TESTING THE QUALITY OF OUR WATER

LAB OVERVIEW

In this lab, students will test the quality of water samples they collect from various locations in their community. Using water quality test kits or strips (NOT PROVIDED WITH THIS CURRICULUM) they will test the water samples for total and free chlorine, hardness, alkalinity, pH, and nitrite and nitrate nitrogen. Depending on the type of water quality test kit or strips obtained by the teacher, other water quality parameters may also be analyzed. Due to the constraints of providing testing equipment for all the schools involved in this program, much of the details of this lab will be up to the teacher. Information for obtaining water quality test kits is provided at the end of this lesson.

LAB PREPARATION

1. Obtain a water quality test kit or test strips which include tests for total and free chlorine, nitrite/nitrate nitrogen and nitrite nitrogen, pH, hardness, and alkalinity. Review the directions for your specific kit or test strips. (Several sources for water quality test kits listed below.)
2. Read all of the Background Information materials (including the Background Information Fact Sheet - *Testing the Quality of Water* as well as the information from your particular test kit).
3. Review the Student Activity Data Sheet - *What's in Our Water* to become familiar with the lab.
4. Gather the materials needed listed below (including making all photocopies).
5. Decide in advance where you will allow (or not allow) students to collect their water samples. Instruct student teams to collect water samples from different areas around the community. For the lab, each team should have at least one water sample, though more may be collected if desired. Samples may be obtained from places such as home water faucets, wells, irrigation ditches, "store bought" water bottles, canals, local streams, etc. Each sample should be collected in a clean jar, which has been carefully washed and dried prior to obtaining the sample (or follow the directions on your test kit). Every sample should be given a number or name. Each label should have the date, sample number, location where the water was collected, and the name of the collector or team for whom the sample was collected.
6. Coordinate the lab station rotation schedule with other "Measuring and Monitoring Environmental Change" Lab Stations. Assign the background reading (Background Information Fact Sheet - *Testing the Quality of Water*) in conjunction with other readings from the different Lab Stations.
7. Review with students the directions for the particular water quality test kit your class will be using.

MATERIALS NEEDED

- Water quality test kit which includes tests or test strips for pH, total and free chlorine, nitrite/nitrate nitrogen, hardness, and alkalinity. (see sources below if your school does not already have a test kit)
- Student Activity Data Sheet - *What's in Our Water?*
- Background Information Fact Sheet - *Testing the Quality of Water*

ACTIVITY PROCEDURE

Note: Students should already have collected their water samples before the lab begins. They should arrive to this station with their water samples.

1. Distribute and review data sheet. As students arrive to this lab, pass out copies of the Student Activity Data Sheet - *What's in Our Water?* Go over the data sheet with students and answer any question.
2. Refer to and review the directions provided with the water quality test kit for conducting the lab tests. It is important for students to know how to use their test kits in advance of beginning this lab. Some test kits require several steps per test. Some kits consist of test strips which just need to be dipped into the sample. Be sure students understand the procedures associated with their kit. Teams should decide who will do which task depending on the directions for their specific test kit.

3. Conduct water quality tests. Have students perform the all the tests for their water sample. They should use their test kits ot test their water for hardness, alkalinity, pH, nitrite and nitrate nitrogen, and total and free chlorine.
4. Record data. Students should enter all their data on their data sheets. When they are done with the lab, they should answer all discussion questions.
5. Conduct class dicussion. As part of the discussion of this lab, have students share the results of their water samples. *How many had results exceeding the standards? What differences were noted among the samples and how does that relate to the location from where the sample was collected?* Review the discussion questions as a class.

EXTENSIONS

Have students use the Student Guide to Environmental Opportunities or other sources to locate and contact someone who works with a local water agency. Student could try to obtain information on local water quality standards, actual water quality data from local municipal sources, and specific information on water qualtiy issues that may be of concern in the area.

SOURCES FOR OBTAINING WATER QUALITY TEST KITS

Carolina Biological Supply Company, 2700 York Roak, Burlington, NC, 27215 USA
(800-334-5551 (U.S.) or 336-584-0381 (International) *http://www.carolina.com/*
Carolina Biological Supply sells a variety of very good classroom water qualtiy test kits. They sell a *9 factor Classroom water Quality Test Kit* which includes test strips for a class of 25 students to test for free and total chlorine, pH, total alkalinity, total hardness, nitrate and nitrite nitrogen, copper, and iron. This Kit sells for $84.00. They also have a *Shirt Pocket Water Test Kit* which includes enough strips to test 10 water samples for free and total chlorine, pH, total alkalinity, total hardness, nitrate and nitrite nitrogen, total copper, and total iron. This kit sells for $25.00. Carolina Biological also sells a variety of other kits including LaMott water quality test kits.

Hach Company, P.O. Box 389, Loveland, CO 80539 USA, U.S. customers: 800-227-4224.
Outside the USA and other inquiries: 970-669-3050. *http://www.hach.com/*
The Hach Company makes a multitude of water qualtiy test kits for classroom, field, and industrial use. They will customize a kit for one's needs. They also have a new, five in one test strip that tests for all the above parameters except nitrogens. Call, check on-line, or write for prices.

Analyticon Instruments Corp., PO Box 92, Springfield, NJ 07081 USA
Phone 973-379-6771 Fax 973-379-6795
E-mail: *info@analyticon.com* website: *http://www.analyticon.com*
Analyticon sells water quality test meters as well as test strips in bulk. They also have an *Educational School Kit for Water Check* that includes test strips for pH, Total Alkalinity, Nitrate/Nitrite, Iron, Copper, Total Hardness, Free and Total Chlorine (60 tests of each parameter) that sells for $79.95. Product number 487-995.

TESTING THE QUALITY OF OUR WATER

The Arizona-Sonora border region is marked by a several large population centers surrounded by wide open landscapes. Though human populations are concentrated in a few relatively small areas, the impacts of human activities on water resources are significant. Threats to water quality in the region stem from a few basic problems: the lack of adequate wastewater treatment for growing populations, increasing industrial output, and outdated agricultural production techniques resulting in overuse of water, high salinity levels, and runoff of pesticides and fertilizers. In some areas, contamination from mining operations and maquiladora waste discharges also pose water quality problems. Additionally, due to the rapidly growing population in border towns coupled with the lack of water deliver systems (infrastructure), many people rely on water that is not treated at all and may contain harmful chemicals and bacteria.

In the United States, the EPA (U.S. Environmental Protection Agency) has the responsibility to maintain water quality standards throughout the United States. Much of their effort is to set the guidelines for proper testing at public water treatment plants and industrial facilities. Even though the EPA has set Primary and Secondary Drinking Water Standards for the water that comes out of your tap, testing in private homes or wells is very infrequent. It has been documented that the water quality of tap water can significantly change between the time it leaves the water treatment plant and when it reaches people's homes.

Poor water quality has been linked to a wide variety of diseases as well as damage to plumbing and fixtures, staining of clothes during washing, and unpleasant taste of food and coffee. Water quality may be tested with easy-to-use test kits which can tell us the actual amount of certain compounds found in the water. The water quality tests presented in this lab are for several basic water qualtiy parameters. These are pH, chlorine, alkalinity, nitrate, and hardness. There may exist many other chemicals in our water, some of which are potentially very harmful such as fecal coliform, arsnic, and tri-chloroethelenes. In this lab, we will not test for such toxic substances. However, the technique for collecting and testing water samples are very much the same regardless of the parameter being tested.

Total Chlorine consists of both free Chlorine and combined (or already reacted) chlorine. The combined chlorine is also referred to as chloramine. Chloramine on occasion may have an objectionable odor that causes the characteristic "chlorine" odor of heavily treated water. Chloramine has less sanitizing capability. The EPA recommends that chloramine levels not exceed 4.0 ppm (parts per million). You can calculate the chloramine level by subtracting the free chlorine level from the total chlorine level. Some municipal treatment plants now add ammonia to chlorine treated water (chlorine and ammonia combine to form chloramine). This sanitation method reduces the formation of THM's(trihalomethanes), which affect the nervous system and muscles and may cause cancer.

Free Chlorine is the sanitizing agent used by most water treatment plants in the United States. Normally (as EPA recommendations) free chlorine levels are above 0.2 ppm at the tap. Levels above 4.0 ppm are considered very high for tap water, yet this frequently occurs if the local water treatment facility has poor chlorination control. If the water sample is drawn from a well or if your water treatment plant uses ozone or another sanitizing method, or if you have a reverse osmosis, distillation, or other filter system at the tap, then the free chlorine level should be 0(zero) ppm. Samples from other untreated water sources will also likely be zero.

Total Hardness (TH) is the measure of the total amount of calcium and magnesium that has naturally leached into well and ground water during its journey through the watershed. TH levels between 50 and 125 ppm are desirable. Low Total Hardness levels (below 50 ppm) can be corrosive to plumbing made from copper, iron, and lead solder. High TH levels (above 250 ppm) tend to form scale inside pipes. After many years, a barrier for the water to flow freely occurs-pipes become clogged. High TH levels reduce the effectiveness of soap or detergents in washing machines and dishwashers and cause spotting of glassware in dishwashers. High TH levels can be corrected with a water softener. The EPA has set no standard for TH.

Total Alkalinity (TA) is a scientific term used to quantify the amount of alkali present in water.TA is also called "buffering

capacity". Moderate amounts of alkali are desirable in tap water because it reduces the corrosive nature of water. Very low levels of TA increase the leaching effect of lead, copper, iron, and other metals from metal pipes into your water. TA at or above 80ppm is desirable. The EPA has set no standard for TA.

pH is the measure of the concentration of hydrogen ions and indicates the acidic or caustic nature of your water. A pH of 6.4 or less indicate that water is acidic will be corrosive to metal plumbing and can cause metals such as lead, copper, and iron to be leached into the drinking water. Water pH levels above 8.5 may tend to leave deposits on fixtures, especially if the TH is also high. EPA recommends that the pH level be between 6.5 to 8.5 pH units.

Nitrate and nitrite nitrogen are chemicals that find their way into the drinking water from farm fertilizer, industrial waste, sewage, biological waste, feed lot run-off, and even some natural forming mineral deposits. Any levels of nitrite or nitrate are undesirable in drinking water. A significant concern with high levels of nitrate nitrogen is its association with other harmful pollutants in water. In most water qualtiy test kits, nitrate nitrogen is determined by subtracting the nitrite nitrogen from the nitrate/nitrate nitrogen. The EPA has set upper limits of 1.0 ppm for nitrite nitrogen and 10.0 ppm for nitrate nitrogen in municipal water supplies.

The above information was derrived from the following sources:

Problems Continue Despite Increased Efforts at Assessment -- Water Quality in the U.S.-Mexico Border Region. BorderLines 44 (Vol. 6, No. 3, April 1996)

Analyticon Instruments. Residential Home Water Quality Test Kit, Information Sheet: *All about Water Qualtiy*. http://www.analyticon.com/aicprods/waterquality/tsktabot.html

Carolina Biological Supply Company, Carolina Shirt Pocket Water Test Kit. 2700 York Roak, Burlington, North Carolina, 27215

WHAT'S IN OUR WATER?

Name _____

Directions: Complete the following below using your water sample. You should work as a team to conduct the tests, but each student should complete his or her own data sheet. Remember to answer the discussion questions after you conduct your tests.

Sample number or name: _____

Location where the water was collected. From where did you obtain your water sample? Describe in detail.

_____

_____

_____

Physical characteristics of the soil. - Describe the following characteristics of your water sample:

Color - _____

Smell - _____

Turbidity (amount of suspended particles as observed by relative clarity) - check one:

_____ very cloudy (can not see through sample due to suspended particles)

_____ partly cloudy (has some suspended particles but can see through the sample)

_____ clear (no suspended particles are clouding the sample)

Follow the directions from your particular water qualtiy test kit and test for each of the following water quality parameters. Enter your results in the data table below:

Water Quality Parameter	EPA Standards	Results from your water sample
Total Chlorine		
Free Chlorine	0.2 - 4.0 ppm	
Chloroamine (reacted chlorine) [total chlorine minus free chlorine]	< 4.0 ppm	
Total Hardness	desirable: 50 -125 ppm no EPA limits	
Total Alkalinity	desirable: >80 ppm no EPA limits	
pH	6.5 - 8.5	
Nitrite Nitrogen	< 1.0 ppm	
Nitrate Nitrogen[nitrate/nitrite nitrogen minus nitrite nitrogen]	<10.0 ppm	

Discussion Questions:

1. Do any of your water quality parameters exceed EPA regulations?
   If your answer is "yes" list the parameters that have either too much or not enough of a specific parameter.

2. Which of all the water quality parameters do you think poses the greatest risk to human health when it does not meet standards? Why?

3. If you had a Nitrate Nitrogen of above 10.0 ppm, what might possibly be the source of excess nitrogen in your area?

4. Why is chlorine added to our drinking water?

5. Did you detect chlorine in your sample? Why or why not?

ENVIRONMENTAL ISSUES INVESTIGATIONS

LESSON OVERVIEW

This lesson provides students with the opportunity to gain valuable information about a variety of regional environmental issues. The class is provided a set of "Case Studies," each which documents a specific environmental issue recognized to be of concern in our Sonoran Desert region. Working in teams, students will select and investigate an issue using their assigned case studies. Also provided with this lesson, are several supplemental readings that include additional information about some of the selected issues. Students may also refer to the "*Student Guide to Environmental Resources and Opportunities*" to contact organizations and scientists working on these issues to gather additional information. Each team will prepare a presentation about their issue to share with the rest of the class. Each student will also complete an "*Issues Investigation Form*" about their environmental issue. Extensions include the opportunity to invite a guest speaker to the class to give a presentation about a selected environmental issue.

TEACHER PREPARATION

✓ Be sure each student has a copy of the following: *Environmental Issues Case Studies*, and Student Activity – Study Guide: *Issues Investigations Form*
✓ Using the teacher's master, prepare copies of the *Environmental Issues Case Studies – Supplemental Readings* (if photocopying is difficult, you may also choose to allow students to read from the master copies)
✓ You may also choose to find additional supplemental readings about the issues to include for your students

TEACHING STRATEGY

1. Introduce this activity. Have students recall the previous two lessons in which they looked at environmental change and measuring and monitoring environmental change. Ask students to consider the kinds of environmental changes occurring in their community and in the Sonoran Desert in general. You may want to have them list some local environmental issues. Explain that this lesson is going to give them an up close and personal look at some real environmental issues that are occurring in our own Sonoran Desert Ecoregion.
2. Divide students into seven teams. Assign each team a specific Environmental Issue Case Study.
3. Review student activity. Have students get out their copy of the Student Activity – Study Guide: *Issues Investigations Form*. Explain that they may work in teams but each student needs to fill out their own form.
4. Review case studies. Explain that as a team, they are to review their assigned Environmental Issues Case Study and prepare a presentation to the class about their particular issue. Students should use their *Issues Investigations Forms* as a guide to help them prepare their presentations. Point out the *Environmental Issues Case Studies - Supplemental Readings* and encourage students to refer to them for additional information. Also encourage students to investigate their issues more extensively by

LESSON OBJECTIVES

Upon completion of this activity, students will be able to:

- list and describe at least three environmental issues relevant to our Sonoran Desert Region.
- analyze an environmental issue in consideration of the resources that are affected and ways to measure and monitor that resource.
- discuss possible resolutions to a diversity of environmental issues.

TIME NEEDED

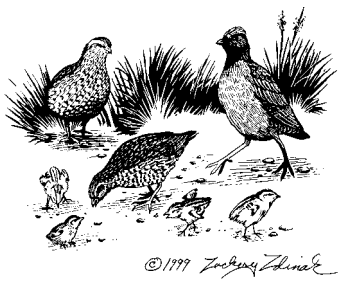
This activity can be completed in one class period if student presentations are brief. It may be preferred to allow one and one-half class periods for longer student presentations of their case studies.

MATERIALS NEEDED

- Environmental Issues Case Studies
- Environmental Issues Case Studies – Supplemental Readings
- Student Activity – Study Guide: *Issues Investigations Form*

CURRICULUM TIES

Arizona: 1SC-D3; 3SC-P1; 3SC-P4; 3SC-D1; 4SC-P6; 6SC-P5; 6SC-P7
O'odham: A.2.8; A.4.3; A.7.3; A.11; B.7.2



referring to the "Additional Resources and References" section of their Case Studies and by referring to the *"Student Guide to Environmental Resources and Opportunities."*

5. Class presentations. Give teams adequate time to prepare their presentations then have each team present their environmental issue case study to the rest of the class. Remind them to use their *Issues Investigation Forms* as a guide in their presentations.
6. Wrap up. Conduct a class discussion on the environmental issues presented. Keep the discussion going by asking students the following questions:

   Which issues had students already heard about?
   Are there other environmental issues in the area that were not included in the case studies?
   Are there other resolutions to any of the issues that had not been mentioned?

EXTENSIONS

More Case Studies. Have students prepare their own Environmental Issues Case Studies on local issues that were not presented in the lesson. Have them research the issues by interviewing local experts, using the library, the internet, or other resources. If thorough enough, you could submit the Case Studies to your Juntos contacts to include in future Juntos publications.

Invite a guest speaker. Have students identify and invite a guest speaker to the class to give a presentation on a specific environmental issue. The speaker may be someone contacted during student investigations or someone that the students choose from the *Student Guide to Environmental Resources and Opportunities*.

LOSING BIODIVERSITY

OVERVIEW OF THE ISSUE

Biological diversity (usually shortened to "biodiversity") is essentially the variety of life. Biodiversity refers to life's variation in genes, species, and ecosystems, all of which contribute to the functioning and balance of the entire planet. Peter H. Raven, Director of the Missouri Botanical Garden and one of the world's most respected botanists, defines biodiversity in the following way:

> *"At the simplest level, biodiversity is the sum total of all the plants, animals, fungi and microorganisms in the world, or in a particular area; all of their individual variation; and all of the interactions between them. It is the set of living organisms that make up the fabric of the planet Earth and allow it to function as it does, by capturing energy from the sun and using it to drive all of life's processes; by forming communities of organisms that have, through the several billion years of life's history on Earth, altered the nature of the atmosphere, the soil and the water of our planet; and by making possible the sustainability of our planet through their life activities now."*

Scientists worldwide agree that biological diversity is very important to the health of the environment. A diversity of organisms, genes, and ecosystems maintains essential ecological processes and life-support systems, protects food supplies, contributes to scientific advances in medicine, agriculture, and industry, and ensures the sustainable use of species and ecosystems which are vital to life. As stated in Chapter 15 of *The Report of the United Nations Conference on Environment and Development* (UNCED), held in Rio de Janeiro in 1992:

> *"Our planet's essential goods and services depend on the variety and variability of genes, species, populations and ecosystems. Biological resources feed and clothe us and provide housing, medicines and spiritual nourishment."*

An area is usually considered "biologically diverse" when it sustains a variety of plants and animals within a diversity of habitats. While some may consider a desert somewhat devoid of life or at least lacking in diversity, here in the Sonoran Desert, just the opposite is, in fact, true. Of all the deserts in the world, the Sonoran is one of the most (if not the most) diverse. The number of different kinds of plants and animal species living here, as well as their growth forms and interactions make for an astonishing diversity of life in this desert. Scientists studying the diversity of different species in the desert, have noted some extraordinary examples of biological diversity in study areas near Tucson Arizona: 1000 ot 1200 species of native bees within a 30 mile radius of Tucson; 630 plant species in a 100km square study area just west of the Tucson Mountains; nearly 100 species of native plants occurring within one acre (0.4 ha); and over 100 species of butterflies in a single canyon. These study areas are but a small example of the diversity of the entire Sonoran Desert.

Although there is tremendous biodiversity in our desert, here, as elsewhere on the planet, that diversity is threatened. While the loss of species to extinction is occurring worldwide at rates never before seen by humankind, the Sonoran Desert is also experiencing decreases in its ecological makeup. In the state of Arizona, 33 animals and 17 plants are currently listed as being endangered of extinction. This does not include Sonora's endangered species such as the totoaba or vaquita or other marine species of the northern Gulf of California. Endangered species in our region include jaguar, Sonoran pronghorn antelope, Gila topminnow, Pima pineapple cactus, cactus ferruginous pygmy owl, and desert pupfish. All these plants and animals are at critically low numbers. Each extinction is irreversible. That species will never again be a part of our desert, our

lives, our planet. The reasons worldwide for the loss of biological diversity are vast and include loss of habitat, over exploitation (hunting or capturing) by humans, and environmental degradation. Here in the Sonoran Desert, the reasons for the decreasing biodiversity are also relatively well known.

One contributing factor to the loss of biodiversity in the Sonoran Desert (as well as other areas) is urbanization and development. Urbanization breaks up vital habitat into smaller fragments. Many species need large tracts of land which, when fragmented into patches because of development and urbanization, become too small to sustain the species. As these fragments of habitat become smaller and farther apart, individuals of the species that once inhabited those areas must either migrate and find new habitat, or die. As an example, fragmentation of habitat and encroaching development is said to have led to the decline of bighorn sheep in the Santa Catalina Mountains near Tucson, Arizona. That population, which once numbered in the hundreds, is down to less than a dozen.

Here in the Sonoran Desert, where there is water, there is life—and a great diversity of it. Be it a spring, ephemeral rain pool, or desert stream, life abounds near the water source. Desert streams support riparian forests which provide habitat to a plethora of insects, birds, fish, amphibians, and mammals. However, as humans use more and more of this water, these "thread of life" in the desert are diminishing. It is estimated that we have lost ninety percent of our riparian habitat in the Sonoran Desert through groundwater pumping and diversion of surface waters. Humans use this water for domestic, industrial, agricultural, and mining needs. However, as our populations continue to grow and our water needs increase, we continue to remove water from the landscape and the desert's diversity of life decreases. Plants and animals reliant on this water simply cannot survive in the desert without it.

Another threat to our region's biological diversity is the introduction and invasion of exotic species. While one may think this might increase diversity, the opposite is actually true. Exotic species can take over an area, out-competing native species, causing their decline and ultimate extinction. Buffelgrass, an introduced African grass species now covers 1,400,000 acres of Sonoran Desert. Most native plants and animals are not adapted to life with this exotic grass and their numbers are declining. Tamarisk is an exotic tree which chokes out the seedlings of native riparian species such as cottonwood and willow. Bullfrogs, introduced to the region from the eastern United States, have completely wiped out some native populations of fish in pools where bullfrogs have proliferated.

These and other threats have a profound effect on our region's biodiversity. There are many reasons to be concerned about the loss of biodiversity. With the irreversible loss of a species goes that organism's genetic codes; its potential to provide humans with medicine, food, recreation, or energy; and its contribution to the overall ecosystem. Some say that regardless of its value to humans, other organisms, or the environment, a plant or animal has a right to be just because it is.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Who is affected by and who affects biological diversity? Although many people are not aware of it, we all affect and are affected by biodiversity. We all need and use water which might otherwise contribute to improved riparian habitat. We all need space to live: a home to live in, roads to travel on, and buildings which house the industries and stores which provide us with the goods and services we need to survive. There are some human activities that have greater impacts on the environment and biological diversity than others, but usually, everyone has some tie (however distant) to activities that adversely affect the diversity of our planet.

Human activities that contribute to habitat fragmentation and degradation, proliferation of exotic species, and excessive uses of water are those that present the greatest threats to biological diversity in our desert region. Among those are industry, development, ranching, and mining. However, while there are some individuals knowingly exacerbating the problem, it is often inapropriate to outright blame developers, ranchers, or miners because, as previously stated, we all are connected to these activities. Cattle and the ranching industry contribute to some habitat degradation, exotic species introduction and water use. Most of us, however, are consumers of the products of ranching. Many ranchers are also greatly aware of the need to protect habitat and biological diversity and are increasingly more sensitive in their practices. Developers who raze huge expanses of land and put in tract homes, parking lots, shopping centers, industrial parks, and golf courses need land for their projects and water for the people to whom they cater. This is land that may be critical habitat to a species. Such development and urbanization also contributes to habitat fragmentation which disrupts species' movements. However, more and more people continue to come to the region increasing the need for housing, shopping centers, etc. and creating these demands met by developers. Mining consumes land and water yet we all use the mineral resources extracted from the earth.

There are some people specifically working on the issue of losing biological diversity. Biologists who study wildlife and plant population make a significant contribution to our knowledge of the environment. Resource agencies that regulate and manage the land and wildlife (such as the E.P.A., U.S. Fish and Wildlife Service, and S.E.M.A.R.N.A.P.) are also focusing efforts on the preservation of biological diversity. Such agencies recognize and protect threatened and endangered species and work to preserve critical habitat.

WORKING TOWARD RESOLUTION

Preserving and protecting the unique biological diversity of our desert region means understanding the threats to diversity and doing something to address those threats. This means reducing exotic species, managing population growth and urbanization, protecting riparian areas and other critical habitat, and learning to use our water resources in a sustainable manner. Additionally, recognizing the issue at an international level, and creating policies to protect biological diversity on a global scale provides needed support and helps drive local research, management, and education activities.

The best example of international recognition of the issue occurred in June 1992 at the Earth Summit in Rio de Janeiro. During that Summit, over 150 nations signed the "Convention on Biological Diversity," which is an international agreement committing governments to comprehensive protection of the Earth's biological resources. The agreement states that participating countries will commit to the development and implementation of national biodiversity plans and strategies; regular meetings of the Parties to the Convention to review compliance and consider actions for implementing the Convention; cooperative partnerships on research and technology transfer; and the provision of new funding for projects designed to implement the Convention in developing countries. Currently, over 160 countries have ratified the convention.

More and more developers are realizing that although development is needed to meet the demands of a growing population, new construction projects can be done in a more environmentally sensitive manner. New developments can include the natural environment and consider native plants and animals in their design. Open spaces with wildlife corridors can be incorporated into most projects. Either through personal insight or public pressure, many developers are seeking environmentally friendly alternatives which can reduce impacts on the area's biodiversity while meeting the needs of the human community.

Another strategy to safeguard our biological resources is through preservation and protection. Both government agencies and non-government organizations have made the effort to set aside hugh tracts of land which sustain sensitive biological areas. Examples of these include the Pinacate, Alto Golfo, and Organ Pipe Cactus Biosphere Reserves; National Wildlife Refuges such as the Buenos Aires, Cabeza Prieta, and Imperial; and privately owned reserves such as the Nature Conservancy's Patagonia – Sonoita Creek Sanctuary. These areas and many more like them are helping provide critical habitat (including riparian areas) for our region's plant and animal communities. Agencies managing these lands also work to reduce exotic species through eradication, management, and education.

Governments, developers, and land management agencies cannot remedy the biodiversity issue alone. Each one of us can contribute by being more aware of the issue and being cognicent of how their own activities may contribute to the loss or protection of biodiversity. By being mindful of how we consume resources such as water, how we recreate out-of-doors, and other consumer choices we make everyday, we can all contribute to the continued existence of a biologically diverse planet.

ADDITIONAL RESOURCES AND REFERENCES

Biodiversity: The Variety of Life that Sustains Our Own. Gary Paul Nabhan *in* A Natural History of the Sonoran Desert. edited by Steven J. Phillips and Patricia Wentworth Comus. Arizona-Sonora Desert Museum Press. Tucson, Arizona. 2000.

Borderlands Biodiversity: Walking A Thin Line. George Kourous *in* BorderLines 43 (Vol. 6, No. 2, March 1998)

http://www.acnatsci.org/erd/ea/biodiv1.html
This is the site of an article entitled*: Biodiversity: Why Should We Care; What Does it Mean?* written by Barry Lewis, Science Writer, Environmental Associates, Academy of Natural Sciences, January, 1997. The artilcle is from a series of articles entitled *"Know Your Environment*" which may be reached through the this webpage.

http://endangered.fws.gov/
The United States Fish and Wildlife Endangered Species Program information page. Lists endangered species by region, education and conservation information, and recent news concerning endangered species in the U.S.

http://www.endangered specie.com
This is a site presenting information and state lists about endangered species.

http://www.cideson.mx/
This is the homepage of IMADES, the Institute of the Environment and Sustainable Development in the State of Sonora. It includes information about protected natural areas in Sonora and maintains a database about the flora and fauna of the region.

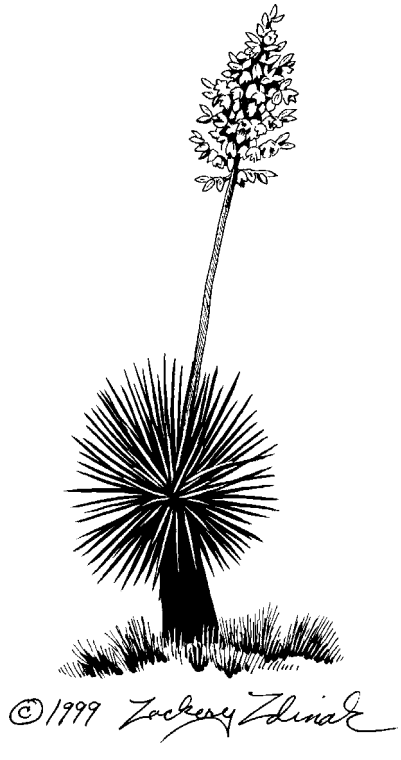
HOME, HOME ON THE CHANGING RANGE

OVERVIEW OF THE ISSUE

Cattle-ranching in the Arizona/Sonora borderland region has been a way of life since before the establishment of Mexico, the United States, and the Tohono O'odham Nation. On their explorations of the New World, Spanish conquistadors brought with them horses, cows, sheep and goats—herbivorous grazers well suited to feed upon the abundant grasses and shrubs. These early arrivals of domestic animals were the beginning of the time-honored tradition of ranching in the American West. Ranching is synonymous with the western United States and northern Mexico, and the lifestyle of the rugged, independent cowboys riding the open range is engrained in the popular culture (songs, stories, sport, dress styles) of the region. Cowboy boots, sombreros, country music, and rodeos are all part of the western experience.
While ranching is a strong legacy of the Sonoran Desert, it is also part of the modern day fabric of life along the border. And though there is a tendency to romanticize the ranching tradition, the face of ranching is changing rapidly and dramatically, especially in the United States. There is also a greater understanding of the serious changes to the landscape caused by centuries of ranching. Cattle grazing has even become a heated environmental issue: environmentalists claim that cattle cause extensive damage to the environment while ranchers uphold that they live close to the land and are thus careful environmental stewards. As with most issues, the truth lies somewhere in the middle.

The cattle boom reached its peak between 1873 and 1893. In Arizona, cattle numbers exploded from about 40,000 in 1870 to 1.5 million in 1891. During this period the ranches were vast and the range was wide open. With such incredible numbers of grazing cattle across the region, vegetation was noticeably affected. The great impact of this period of ranching is still visible in the landscape. However, grazing alters the natural environment not only historically, but presently as well. Our knowledge of the consequences of grazing the land has grown: it has become increasingly necessary to understand just how the environment is affected by cattle and other grazing animals. Just as ranching has developed over hundreds of years, so has the practice of range management.

Range management is an area of ecology that looks at grazing and the range environment. Studies have shown that livestock grazing has resulted in a number of impacts on the grasslands of southeastern Arizona and northern Sonora. One thing that scientists have noted in the increase of woody species such as mesquite and juniper. A combination of factors is responsible, with wildfire and grazing being key. Fire was a dominant natural force that shaped Western grasslands before Europeans arrived. However, overgrazing reduced the grasses, which fueled the fires, lessening the ability of the rangelands to carry fire, and lowering the temperatures of fires that did occur. Humans have also suppressed fires that otherwise would have burned thousands of acres. Trees that would have been eliminated given an uninterrupted fire regime have had the opportunity to grow. Cattle also help spread trees such as mesquite by eating the seeds, transporting them to new sites, and depositing them in a heap of "fertilizer." Livestock also tend to compact the soil with their hooves, which often results in a reduction of soil moisture in the upper layers of the soil therefore favoring deeper-rooted plants (the more woody species).



Cattle may have serious impacts on the land they graze but the extent of that impact is dependant largely on the kind of land that they are allowed to graze. Cattle are able to graze on land unfavorable for farming either due to the topography or lack of accessible water. However, when unrestricted, they tend to prefer areas closer to water for the availability of forage, water, and shade. It is these areas however, that are the most sensitive to the impacts of livestock. One of the biggest debates about grazing is allowing cattle to graze in "riparian" areas (green, tree-lined areas next to and dependent upon water courses). It is said that cattle pollute the water, cause bank erosion, and trample young riparian species. Some managers feel it is important

to keep cattle out of sensitive, riparian areas.

A two-year-long study examining sites on both sides of the US/Mexico border led a team of ASU researchers to conclude that overgrazing in Mexico is making the Sonoran Desert warmer and less productive along the border between Arizona and Sonora. The researchers reported a self-perpetuating cycle of desertification in which overgrazing reduced vegetative cover, which degraded the soil, resulting in warmer temperatures, which in turn degraded plants and soils even more. However, Jeffrey Klopatek, ASU professor of ecology and leader of the study said, "Desertification is not uniform along the whole border. There are some areas where it is not occurring because they practice good range management."

Good range management is the key to this issue. Formerly, grazing practice was open range, meaning that cattle were allowed to graze freely with few or no fences restricting their movement. Now, most ranches and grazing pastures are fenced, allowing ranchers to select where they will graze their cattle. This also allows ranchers to keep cattle off sensitive areas. In fact, in many places in the West, it has become necessary to completely remove cattle from the range in order to allow the landscape to recover from grazing impacts.

It is widely accepted among ranchers, scientists and environmentalists that the grazing of cattle has impacted the rangelands of southern Arizona and northern Mexico. However, with recognition of the consequences of grazing comes an effort to resolve the negative impacts. By instituting environmentally sound management techniques (e.g. fencing cattle out of sensitive habitat or frequent rotation of herds between pastures) it is hoped that the land may be restored as well as protected for future use. The issues still persist between ranchers and environmentalists however, and it will only be through better communications and a greater understanding of grazing's short and long-term impacts that resolution may arise.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Interested parties in the range management issue include ranchers, environmental organizations, public land stewards, and developers. Of course, those who have the greatest responsibility for livestock and the impact they have on the land are the ranchers who depend on these animals for their livelihood. Many ranchers are very conscientious range managers; they're proud of their occupation, they love the land, and are keenly aware that they must take great care of the land if it is to continually support their livestock. Yet there are many different ways of ranching. Some ranchers may view the animals as the main investment and place a greater priority on the health of the livestock than the health of the land that supports them. More and more, ranchers are coming to realize that the health of the two is intertwined.

Recently, environmental groups have focused attention and sometimes criticism on ranching practices. Some environmentalists have taken aim at ranchers, lumping all ranchers together and accusing them of being involved in a business that degrades the land. The paradox of this is that often the environmentalists are city dwellers who have little understanding of ranching techniques and the rural, ranching lifestyle. Ranchers have been offended by "city-slickers" interfering with their business and way of life. However, environmentalists often have sound scientific research informing their opinions. It is important for environmentalist to be rational and not emotional about the issue and make an effort to be constructive in their criticism of ranching.

One point of contention between ranchers and environmentalists is grazing on public lands. In Arizona there are three governmental agencies that administer public rangelands - the Bureau of Land Management, the U.S. Forest Service and the Arizona State Land Department. For a fee, ranchers are allowed to graze their livestock on selected lands managed by these agencies. Environmentalists contend that the fees are too low and do not account for the damages incurred on the land by the cattle. Agencies are thus often blamed for contributing to the issue.

In United States, some ranches are being forced into closure. Whether through lack of family to carry on the tradition, lack of funds for the land taxes, or being forced out of business due to inadequate grazing land or other economic reasons, some ranchers have had to quit their operations and sell their ranches. One party benefiting from this has been developers. Some of the most beautiful land in the region are former ranches which, when bought up by developers, are often subdivided and turned into housing areas and other developments. It is a sad irony for environmentalist trying to discourage grazing only to witness loss of the open range to subdivisions and urbanization.

WORKING TOWARD RESOLUTION

In order to resolve the complex issues surrounding range management, alliances have been formed among ranchers,

environmental groups, and governmental agencies. This appears to be one of the most positive steps towards resolution. Additionally, better range management practices and increased awareness through education are helping to restore and protect areas historically overgrazed. Activities on the Tohono O'odham Nation exemplify such efforts.

Two examples of alliances include the Malpai Borderlands Group and the Arizona Common Ground Roundtable. The Malpai Borderlands Group consists of landowners and other partners from the private sector, and local, state, and federal land management agencies. It began in 1993 in an effort to address threats to ranching by educating, looking for common ground, and by collaborating with local, state and federal agencies, universities, and environmental organizations. The Group's goal is, "To preserve and maintain the natural processes that create and protect a healthy, unfragmented landscape to support a diverse, flourishing community of human, plant, and animal life in the borderlands."

The Arizona Common Ground Roundtable is a statewide policy dialogue among ranchers, environmentalists, researchers, public agency personnel, sportsmen and other interested citizens. A common ground has been discovered among these interests - a deep concern over the rapidly accelerating loss of open spaces in Arizona. Participants are seeking to identify tools and policy changes that will conserve the open spaces on which Arizona's flora and fauna, water supply, and scenic beauty depend.

On the Tohono O'odham Nation, the history of cattle grazing has been one of open, communal grazing. However, according to Kristen Eagen, range management specialist for the Nation, in the 1970's the tribe began to managed a "tribal herd" and adopted better monitoring, breeding, and grazing practices. Additionally, given that there are other herds on the districts across the Nation, there has been discussion about increasing the fencing on the nation and limiting grazing on open range. Encouraging long-time O'odham ranchers to change and adopt better management practices is the challenge currently being faced by the Nation's Natural Resources Department. Historically there have been no long-term incentives or funding for range improvements. Thus the key to better management will to a great degree depend on education of ranchers in the outlying communities. An outreach program is currently being conducted through the Natural Resources Department to improve range management on the Nation.

Efforts in education, range conservation research, and collaboration all contribute to the resolution of grazing issues and the long-term stewardship of the land. Experience shows that ranching is not an inherently destructive occupation. As with any business, it is the way in which ranching is conducted that determines the impacts of grazing on the environment. Ultimately, when ranchers take care of the land, the land takes care of them.

ADDITIONAL RESOURCES AND REFERENCES

Dagget, Dan "Beyond the Rangeland Conflict: Toward a West that Works," The Grand Canyon Trust, Flagstaff, AZ, 1995.

"Overgrazing is Tied to Border Desertification," Arizona Daily Star, Tim Steller, Jan. 31, 1999.

http://udallcenter.arizona.edu/commonground/home.htm
This site, maintained by the Udall Center for Studies in Public Policy, provides information about the Arizona Common Ground Roundtable. It includes links to other resources.

http://geochange.er.usgs.gov/sw/responses/malpai/
This USGS website presents an overview of the Malpai Borderlands Group and Project. Included are links to other sites with rangeland information.

http://www.ranchwest.com
Ranchwest: Living in Harmony with Nature. This website is the product of Nol Ward, a longtime rancher who strongly believes in economically, socially and ecologically viable beef cattle ranching.

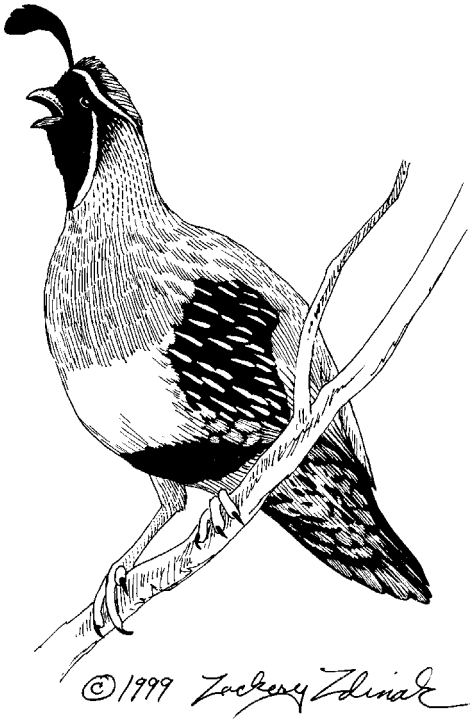
INVASION OF THE EXOTICS, INTRODUCTION OF NON-NATIVE SPECIES OF PLANTS AND ANIMALS

OVERVIEW OF THE ISSUE

"Exotic", "alien", "introduced", "non-indigenous" and "non-native" are all words used to describe species of plants and animals that are intentionally or unintentionally brought into an area that is outside of their natural range. The invasion of exotic species is a serious issue in practically every ecosystem throughout the world. For example, in the Galapagos Islands, the population of introduced goats has exploded from zero twenty years ago to approximately 40,000 today. Because the goats eat so much of the vegetation, the survival of the herbivorous, native Galapagos tortoise is threatened. Another example is from Australia. Although a somewhat isolated continent, Australia now has over 70 species of exotic marine organisms. One of the most recent invaders is the North Pacific Seastar, which arrived around 1980 presumable in ballast water from Japan. The seastar population has exploded to densities of over 24 individual per square meter. It is a top predator and is decimating Australia's reef ecosystem.

Here in our borderland region of the Sonoran Desert, the problem is considered to be one of the most serious of all threats to the biological diversity of our native species. It is estimated that there are at least 400 species of plants and animals that now occur in the Sonoran Desert that are not native to this region. We have grasses from Africa, trees from Asia and Australia, birds from Europe, and even bullfrogs from the eastern United States. In fact, many plants that seem very common to us are actually not from here at all. The ubiquitous "tumbleweed" is actually from Russia. Bermuda grass comes from Africa. Date palms originated in the Middle East and were brought to our region by early Spanish missionaries.

How do plants and animals get relocated to areas so far from their native origins? Many species are inadvertently introduced though human travelers shipping agricultural goods or other products globally. Seeds get transported in packaging material, bags of crop seeds, and as accidental hitchhikers on the wheels of vehicles and planes, or on the hooves of livestock. Ships using water as ballast carry water from all around the world in their holds which, when released into a different port, may introduce exotic marine species which were transported in the ballast water. Additionally, many species are relocated on purpose, usually with the belief that the introduced species would somehow improve the environment, either through reducing erosion, improving forage opportunities for range animals, or simply for aesthetic reasons.



Why are introduced species considered an environmental problem? What's wrong with a few different plants and animals in our landscape? The problem is that there are typically more than a just few individuals of these invading species. In many cases, introduced species are so successful in their new environments that they may cause the extirpation or extinction of native populations. Many introduced species quickly adapt to their new homes and are able to out-compete natives species for food, space, and other natural resources. Some introduced species prey on native wildlife. In many cases, the native animals are not adapted to avoiding the new predator and in some instances; native species have been completely wiped out by exotic predators. Introduced plants often disrupt natural processes such as how and where native seeds germinate and how rain waters flow and infiltrate. Some introduced species hybridize with natives altering the genetic makeup of the native species. Diseases and parasites may be spread to native populations by exotics. Clearly there are numerous problems with invading exotics.

The problem has been slow growing. The European starling was introduced into New York's Central Park in 1890, when 60 birds were released with the intent to bring every bird ever mentioned in Shakespearean literature into the United States. As a result, starlings are now one of the most numerous birds on the North American continent and have proven to be an agricultural

nuisance as well as a successful competitor for food, space and other resources. The starling displaces many native species of birds (including our native Gila woodpecker). Another example is the introduction of buffelgrass into Arizona and Sonora in the 1930's. Scientists hoped the grass would provide livestock forage and curb erosion. The grass quickly spread from experimental plots in Tucson, Arizona and ranches in Sonora. Today buffelgrass can be found throughout the Sonoran Desert—even in remote wilderness areas. Although the grass is good for livestock, it greatly alters natural desert ecosystems. Buffelgrass competes with native plants for water, nutrients, and space. It forms thick bunches under which native seedlings cannot germinate and native lizards cannot warm themselves. Animals that prefer desert ecosystems are replaced with those that prefer grasslands. The grass also alters deserts by increasing the intensity and frequency of fires. The grass helps spread fire and quickly reestablishes itself after a burn—while the natives die and take years to grow back. Other examples include tamarisk trees, which were brought from the east to control erosion and have invaded riparian areas in the Sonoran Desert, and bullfrogs, which were brought into Arizona in 1926 as a game animal. Bullfrogs have voracious appetites and decimate populations of native frogs and fishes. The list goes on and on. According to Gary Paul Nabhan, Director of Conservation and Science for the Arizona-Sonora Desert Museum, "*Few people understand the severity of the current impact of exotics upon natives in the U.S. / Mexico borderlands*." In one study in Tucson, Arizona 52 exotic species were documented in a study plot. When the study began in 1909, there were only two exotic species in the area. During the same time, 20 native species were completely lost from the site. According to the scientists conducting the study, these changes reflect what is happening throughout the Sonoran Desert and they appear irreversible. The problem is serious.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Although it may be thought that only biologists and other scientists are concerned with these issues, the problem affects everyone. According to United States Department of the Interior, "*invasive plants inflict a heavy toll on American agriculture, reducing the quality and raising the cost of food, feed, and fiber*." Experts estimate that invasive plants already infest over 100 million acres. Three million acres are lost to invasive plants each year. The total economic impact of invasive plants on the U.S. economy is estimated to be about $123 billion annually. Invasive animal species wreak billions more in damage to crops and rangeland. Mexico is equally affected by exotics.

WORKING TOWARD RESOLUTION

Because the problem is now recognized to be very serious and of global concern, in the United States, former President Clinton signed an Executive Order on Invasive Species in 1999. The order supports federal actions including "measures to prevent the entry of invasive species, eradicate invasive species before establishment, control invasive species once established, and conduct outreach and education for the general public." Mexico does not yet have a national agenda although there are regional strategies to combat invasive species focusing on research and education.

As mentioned above, resolution strategies include prevention, eradication, control, and education. Prevention involves creating and enforcing stricter laws regarding transportation of potential carrier mechanisms. It involves such activities as increasing inspections at ports of entry and restricting use of packaging materials that may harbor exotic pests. Eradication involves removing invasive species by hand, using chemicals, or using biocontrols (such as natural predators). Control is similar to eradication and may involve similar strategies to keep an exotic species from becoming too numerous. Education involves increasing the awareness of not just ranchers, farmers, industry, and agricultural inspectors, but the general public as well.

Here in the Sonoran Desert, there are increased efforts to address the problem of invasive species. Organ Pipe Cactus National Monument has taken a very aggressive stand in its efforts to control buffelgrass on the Monument. Through thousands of hours of human effort over the past four years, it is estimated that 100 tons of buffelgrass have been removed (by hand!). A similar program at the Hassayampa River Preserve in Wickenburg, Arizona involves volunteers in "tammy-whacking"—chopping down the invasive tamarisk trees. In Sabino Canyon and other small streams in Arizona, exotic fish are being shocked, netted, or poisoned to remove them from the habitat. Research is being conducted throughout Arizona and Sonora to determine which exotic species are most threatening and what are the best methods of control and eradication. Education about the problem is also increasing. Addressing the problem will require efforts on all fronts.

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Buffelgrass, Bullfrogs, and other Bioinvaders of the Sonoran Desert. Sonorensis. Arizona-Sonora Desert Museum. Winter 1999.

Invasive Exotic Plants Are Destroying the Naturalness of U.S. Wilderness Areas. Jerry E. Asher and David W Harmon. International Journal of Wilderness. December 1995

http://www.aphis.usda.gov/ppq/weeds/weedhome.html
This is the homepage of the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service's (APHIS) noxious weeds program. To contact APHIS locally:
Joel Floyd, Area Identifier
USDA APHIS PPQ
9 N. Grand Ave. Rm. 2214
Nogales, AZ 85621
(520) 287-4783

http://bluegoose.arw.r9.fws.gov/ficmnewfiles/natlweedstrategytoc.html
This is the web page for Pulling Together – National Strategy for Invasive Plant Management. There is also a hard copy document of the same name.

http://www.nbii.gov/invasive/index.html
The Invasive Species homepage of the National Biological Information Infrastructure (NBII). "The NBII is an electronic gateway to biological data and information maintained by federal, state, and local government agencies; private sector organizations; and other partners around the nation and the world."

http://jasper.stanford.edu/gisp/
Global Invasive Species Programme. GISP is a collaboration of international teams coming together to address the invasive species issue. The results of their work will be disseminated via published reports, international meetings, and especially through a new network of information exchange and training to be developed as part of the project.

AIR QUALITY, CONCERNS IN THE SONORAN BORDERLAND REGION

OVERVIEW OF THE ISSUE

The air that we breathe supplies the oxygen our bodies need to survive. Air is all around us, a vital resource that is difficult to manage and control. Air pollution, which can affect our bodily health in various ways, is becoming a growing concern in our Sonoran Desert borderland region. When our local air is polluted, we have no other choice than to breathe it in. This suspended pollution can also settle onto the crops we eat, contaminate the water we drink, and affect the natural environment. Local air quality, direct or indirect exposure, and the length of time one has lived under such circumstances largely determine the health risk for an individual. Direct exposure to a large amount of hazardous fumes could result in immediate health problems, and the effects of inhaling contaminated air over time could be chronic, showing up many years later.

Air pollution comes from various sources such as gasoline-powered engines in automobiles, dust from paved and unpaved roads, small and large businesses, chemical and solvent use, coal, trash, and wood burning, and swimming pool chlorination. Air pollution comes in different forms, from released gases to small and large particles. Hazardous Air Pollutants (HAPs) are gases or particles in the air such as chloroform, benzene, and arsenic that threaten human health. The six designated "criteria pollutants" that tend to be of the greatest concern are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), lead (Pb), and particulate matter (PM_{10}). The last one, PM_{10}, consists of very small particles (less than 10 microns) that come from various sources, some induced by human activities such as mining, trash burning, farming, or driving on a dirt road, and others from natural causes such as wind-blown dust. PM_{10} is a major cause of air visibility problems. These particles are of concern because they are so small that we can breathe them into our respiratory tract, which can contribute to coughing, shortness of breath, asthma, lung damage, and nose and throat problems. Particulate Matter under 2.5 microns ($PM_{2.5}$) is especially dangerous because these minute particulates can be breathed deep into the lungs.

The United States and Mexico have set national standards to regulate the quality of the air we breathe. In the United States, the Environmental Protection Agency (EPA) set the National Ambient Air Quality Standards (NAAQS) that determine the acceptable levels of the six criteria pollutants in the air. Each state must formulate a plan to meet these national standards and submit an annual summary of air quality levels. In Arizona, the Arizona Department of Environmental Quality (ADEQ) monitors air quality, issues permits, and helps to develop and implement programs to significantly improve air quality in the state, with the hopes that the air will be clean enough to pass inspection. However, at the end of 1999, various locations in southern Arizona were on the list of 119 national non-attainment areas, meaning that they continuously did not meet acceptable levels with one or more of the criteria pollutants: Phoenix (O_3, CO, PM_{10}), Douglas (PM_{10}, SO_2), Yuma (PM_{10}), and Nogales (PM_{10}). When this is the case, the state must submit a State Implementation Plan (SIP) with detailed information of the nature and sources of this pollution as well as a strategy of how it can be lessened.

In Mexico, recent industrialization and urbanization (the mass movement of people from the countryside to the cities) have led to rapidly rising levels of air pollution. With the national focus on industry and growth, environmental concerns such as air quality have been less of a priority. In the 1980's, air quality was measured more carefully as a response to the growing air pollution in Mexico City. Today the National Institute of Ecology (INE), a governmental agency under the Secretariat of the Environment, Natural

Resources, and Fisheries (SEMARNAT), works to incorporate strategies, education, and technology that improve air quality—especially in large urban areas like Mexico City, Guadalajara, and Monterrey. In such places, the INE has focused on decreasing the amount of lead (Pb), sulfur dioxide (SO_2), carbon monoxide (CO), and total suspended particulates in the air. Mexico has similar air quality standards to those of the United States, but with slightly stricter criteria for sulfur dioxide (SO_2) and ozone (O_3). A binational report prepared for 1996 indicated that the border cities of San Luis Rio Colorado (PM_{10}), Agua Prieta (PM_{10}, SO_2), and Nogales, Sonora (PM_{10}) all exceeded or potentially exceeded Mexican air quality standards for the criteria pollutants listed above.

As we have seen, along many parts of the U.S.-Mexico border, air quality is often poor, does not meet national standards and threatens the health of border residents. More people, new industries, and increased traffic as well as the difficulties of binational cooperation have contributed to border air pollution problems. In addition, the unique conditions here in the Sonoran Desert have exacerbated the problem. High levels of dust and particulates are naturally in our desert air, and there is little rain to help decrease these levels. The size of a city or town and the amount of traffic in it are generally good indicators of air pollution levels. However, there may also be particular local factors that influence air quality, such as the mining near Ajo, the agriculture and wood burning in Sonoyta and San Luis Rio Colorado, and the growing number of maquiladoras in Agua Prieta.

From 1994 to 1999 the Arizona Department of Environmental Quality (ADEQ) worked together with Mexico's SEMARNAP to study the air quality in Ambos Nogales. More specifically, it sought to investigate the effects that the hazardous air pollutants (HAPs) and fine particulate matter (PM) have on the health of local residents. The study indicated that the excess cancer risk from HAPs to a typical resident in Ambos Nogales is quite small, although it is higher than the risk in Tucson and Phoenix, Arizona (See graph above). The major source of both cancer and non-cancer risks from HAPs is the compounds released from motor vehicles that people inhale. PM_{10} in Ambos Nogales primarily comes from unpaved road dust, yet dust stirred up from paved roads is also a significant source. The study stated that typical exposure to PM_{10} could potentially lead to increased pre-mature deaths due to cardiovascular and respiratory problems on both sides of the border.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Air pollution affects individuals, communities, governments, and businesses as well as animals, plants, and other natural resources. No person who lives in a city with serious air pollution problems can avoid breathing pollutants into his or her body. Although sensitive children, elderly people, those with cardiovascular and lung disease, and workers with excessive exposure to HAPs are generally the most at risk from air pollution, long-term exposure threatens even strong and healthy people. Every year billions of dollars are spent to try to repair the damage to bodies, buildings, cities, forests, and crops that is caused by air pollution. Many companies and industries have been forced to implement costly strategies to comply with emissions standards that are becoming increasingly strict. So, not only are most of us are affected by air pollution, we are also contributors to this problem. The complexity of this issue becomes evident when we realize that we all want to breathe clean air, yet at the same time our lifestyles often include eating food that is trucked in from afar, using electricity from power plants, commuting across town to work or school, and buying products from industries that pollute our environment.

WORKING TOWARD RESOLUTION

In 1983 under the La Paz Agreement, the Mexican and United States' governments first started working together on air quality problems along the border. In 1996, both countries initiated the joint Border XXI Program, whose main goal is "to promote sustainable development by seeking a balance among social and economic factors and the protection of the environment in border communities and natural areas." Under the Border XXI Program, the Air Workgroup coordinates short and long-term projects with non-governmental organizations and local and state governments in each country in order to improve border air quality. The Air Workgroup sets up and maintains monitoring stations, tests new air quality models, provides technical support, and continues to study ways to improve the current situation.

In response to pressing air quality challenges in large cities, the Air Quality Metropolitan Index (IMECA) was established in Mexico to measure the level of pollutants and inform the public of related health risks. The Index has a scale from 0-500: a reading of 0-100 indicates satisfactory air quality (conditions that are safe for outdoor exercise) and a measurement of 301-500 means that the air quality is very bad (potentially leading to symptoms and problems for otherwise healthy people). Air quality reports are published daily in the media so that people understand the level of risk. In Mexico City, one of the largest cities in the world, the Automatic Atmospheric Monitoring Network (R.A.M.A.) automatically measures air quality levels every minute at 33 sites in the metropolitan area. If levels become extremely dangerous for all people living there, an emergency program

takes effect that by law limits the use of vehicles and industrial activity. According to license plate number, all vehicles in Mexico City are prohibited from driving one day a week; during dangerously high levels of air pollution, vehicles can only drive every other day.
In 1990 the United States implemented the Clear Air Reauthorization Act that ambitiously set out to drastically reduce air pollution by the year 2005. It requires tougher emissions standards for automobiles. Every year or two car owners must take their car to get tested to see if it is polluting the air over acceptable levels. The Act also requires the petroleum and auto industries to develop cleaner burning alternative fuels as well as vehicles that can use this fuel. City buses in Tucson, Arizona now largely use Compressed Natural Gas instead of diesel, which helps to reduce air pollution. The Act also gives the Environmental Protection Agency (EPA) more authority to enforce these standards and penalize those industries and people who are not in compliance. In addition to the National Ambient Air Quality Standards (NAAQS), the EPA developed a scale from 0-500 called the Air Quality Index (AQI), which translates the air pollution threats into one measurement system. This informs experts and the general public of the current health risks from breathing in air. Over 1,000 sites in the U.S. measure common pollutants and calculate the local AQI reading.

Individual choices can also play a significant role in improving air quality. Greater access to information and educational programs that raise awareness about air pollution can help individuals make connections between the choices they make in their daily lives and the quality of the air they breathe. If a car-owner understands that automobile emissions is a major source of air pollution, he or she can begin to use alternative modes of transportation whenever possible, such as taking the bus, riding a bike, walking, and carpooling. When driving, that person can make sure that the vehicle is tuned and the tires are properly inflated. Avoiding quick starts and stops, especially on dirt roads, is a way to reduce the amount of PM_{10} in the air. Finding alternatives to burning trash, burning less wood, and not letting fires cool down and smoke a lot are other ways to lessen air pollution. Conserving energy by using less electricity will lead to less emission from power plants. Using environmentally safe paints and cleaning products also means cleaner air.

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Ambos Nogales Binational Air Quality Study: Citizen's Summary. August 1999.
*(Available as supplemental reading in the JUNTOS Teacher's Guide)

http://www.irc-online.org/bordline/index.html
Binationally Managing Air Quality in the U.S.-Mexico Borderlands: A Case Study. Borderlines. January 2000.

http://www.epa.gov/usmexicoborder/indica97/chap2.htm
U.S.-Mexico Border Environmental Indicators 1997 is a binational U.S.-Mexico Border XXI Program report. Chapter 2 focuses on air quality standards, reports, and criteria pollutants in the border region.

http://www.epa.gov/ttn/catc/cica/
CICA "provides technical support and assistance in evaluating air pollution problems." This U.S. EPA site offers U.S.-Mexico Border air quality information and resources in English and Spanish.

http://www.sima.com.mx/sima/df/index.html
The Climate Institute's bilingual website offers today's air quality readings from different locations in Mexico City. Background information and Mexico specific programs and challenges are also addressed.

http://www.epa.gov/airsdata/
"AIRS*Data* gives you access to air pollution data for the entire United States." This EPA website offers information for the public on local air quality monitoring and sources of pollution.

Subcomité de Salud y Medio Ambiente del Consejo Binacional de Salud de Ambos Nogales
This non-governmental organization promotes the cause of environmental health issues on both sides of the border and focuses on issues in the community such as air quality that affect quality of life. It has articles and reports of environmental health research available.

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Environmental Committee of the Rio Colorado Commission

This non-governmental organization serves the international area of Yuma, Arizona and San Luis Rio Colorado, Sonora. It has various binational committees and works with air and water quality among other issues.

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ENVIRONMENTAL HEALTH ISSUES ALONG THE U.S-MEXICO BORDER

OVERVIEW OF THE ISSUE

During this past century, human population along the U.S.-Mexico border area has increased at phenomenal rates. In 1900, approximately 36,000 people lived along the entire border. Today the border population is estimated to be near 10,000,000 inhabitants, with many of these people arriving the last 40 years. Along with this population increase, the border area has experienced rapid industrial development. Both the Mexican and American governments have encouraged economic growth in this region, primarily in the form of industrialization and large factories called *maquiladoras*, or "twin plants". (Note: As of 1997, there were 168 *maquiladoras* in Nogales, Sonora and 24 in San Luis Rio Colorado, Sonora.) Because of the increased job opportunities associated with border industries, more and more people continue to come to the border cities. While the benefit of these factories has been to provide more jobs for more people, they have often failed to take into account the consequences that such a rapid rise in population and industry would have on the environment and to public health. Much of the growth in the border region has been unmanaged and has resulted in serious environmental problems, which threaten the health of border residents.

The issue of environmental health along the border is so serious that it is a major focus of U.S. and Mexican federal environmental agencies. According to the U.S.-Mexico Border Environmental Indicators 1997 report, published by the United States Environmental Protection Agency (EPA) and Mexico's Secretariat for Environment, Natural Resources and Fisheries (SEMARNAP), "The border region is confronted with a number of serious public health problems that are or may be associated with toxic environmental exposure. Contamination of air, water, and soil by hazardous materials and waste, pesticides, nitrates, raw sewage, untreated wastewater, parasites, or bacteria are suspected to be key factors contributing to the presence of certain diseases in the populations residing along the border. These diseases include… elevated blood lead levels in children; multiple myeloma, a form of bone-marrow cancer; systemic lupus erythematosus, an autoimmune disorder; hepatitis A; infectious gastrointestinal diseases such as shigellosis and amebiosis; and pesticide poisonings." The contaminants listed above are mostly, if not all, a result of the rapid increase in population and industry in the region. More people means increased consumption and more waste generated and growing industry has resulted in often-toxic industrial wastes released into the environment.

Perhaps one of the most pressing examples of an environmental health risk is that of water contamination and water shortages. Cities require basic "infrastructures" to accommodate their human inhabitants. A city's infrastructure includes such things as water delivery systems, sewerage systems, electricity, and waste treatment facilities. In most rapidly growing border cities, the infrastructures have been unable to keep up with and adequately serve the number of people living there. Many residents in border communities live in *colonias*, or other unplanned neighborhoods that are often without sewer hook-ups or running water. Water shortages in these households make it more difficult to maintain sanitary conditions, such as having a clean kitchen or safely disposing of human waste. This increases the likelihood of health problems such as gastrointestinal diseases and parasitic infestations. In addition, household wastes and sewage from neighborhoods without water and sewer hook-ups are more likely to contaminate the city's water supply. Other large sources of water contamination are *maquiladoras* and other businesses that release untreated industrial waste into public waterways. Public health officials believe that improving such water-related problems will lead to a better quality of life and greater personal health for border residents.

These problems usually affect both sides of the border, as is the case in the border cities of Ambos Nogales (Nogales, Sonora and Nogales, Arizona). Although on different sides of the border, these sister cities share the natural resources of the area. Both communities depend upon the same underground water supply and both use the north-flowing Nogales Wash as a major drainage system. The majority of *maquiladoras* are located in Nogales, Sonora, where there are also many *colonias* in the hillsides. From these and other sources, untreated sewage and hazardous waste collected by rainwater may flow through Nogales Wash north from

According to the EPA report "U.S.-Mexico Border Environmental Indicators 1997," in 1996, only 64% of Nogales, Sonora residents received potable water in their homes and only 81% of residents received wastewater (sewage) services.

Sonora into Arizona, thus posing a health risk for residents on both sides of the border. In 1994, for example, potentially explosive fumes in the Nogales Wash, due to petroleum products released upstream, forced nearly 2,000 people to evacuate downtown Nogales, Arizona.

Border areas such as Ambos Nogales and San Luis Rio Colorado / Yuma face many environmental health challenges in the future. The populations of these border cities continue to grow at exponential rates. As more and more people continue to come to these border cities seeking work, the more difficult it will be to provide adequate water and sewage services to area residents. Yet experts agree that to reduce the number of diseases and illnesses in these areas, we must improve the basic infrastructures, especially water delivery and sewage disposal systems. Additionally, factories must improve their waste disposal techniques to further ensure human health.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Border environmental health problems are of concern to long-time local residents, *maquiladora* workers, governments on both sides of the border, and others. Local residents have seen their towns grow immensely during the past few decades. This growth has meant economic gain, but also many new problems such as a dwindling water supply that is threatened by a greater risk of contamination. *Maquiladora* workers have often come from other parts of Mexico in search of a job with higher pay, and some of the only affordable housing close to work is in the *colonias*, where poor drainage and no running water often increase the risks of illness and disease. Though immigrant maquila workers are providing a valuable service to the industry, their increased numbers add stress to the already over-loaded infrastructure. Lastly, the Mexican and U.S. federal governments have encouraged economic growth along the border, but local governments often do not have enough resources and financial support to solve their environmental problems. This gap between local and national governments as well as the differing national priorities and regulations in Mexico and the U.S. tend to present obstacles for local governments and organizations to successfully cooperate on these important environmental health issues.

WORKING TOWARD RESOLUTION

The Mexican and United States' governments have recognized that environmental health is an important issue and have agreed to work together on resolution strategies. In 1983 the two countries signed the La Paz agreement, which was designated as the "Agreement between the United States of America and the United Mexican States for the Protection and Improvement of the Environment in the Border Area." In the 1990's, the Border Environmental Cooperation Commission (BECC), made up of official and non-governmental representatives from both countries, was created. The BECC has worked on border projects focusing on wastewater treatment, water supply, and municipal solid waste. In 1996, the Border XXI program was initiated by the U.S. EPA and Mexico's SEMARNAP. Border XXI is a binational interagency program aimed at protecting and improving the environment and environmental health while fostering sustainable development in the U.S. – Mexico border area.

An important part of protecting environmental health is enforcing existing regulations. Both the U.S. and Mexican governments have inspection and enforcement programs aimed at ensuring compliance of environmental regulations by *maquiladoras* and other industries. In 1997 alone, Mexico reported 3,323 environmental inspections and the U.S. reported 623 inspections. The important thing is that both countries took "enforcement actions" when industries were non-compliant. It is vital that industries know they are being watched and must account for their actions. However, few regulations exist or are enforced at the neighborhood level.

Another strategy, which has been successful in some communities, is improving health conditions through the training of local community health workers, or *promotoras*. These *promotoras* are respected citizens who live in the town where they work and therefore understand the culture, lifestyle, and problems of their community. These *promotoras* become an important link between the border residents and health practitioners. They can identify the needs of the community for the health care system. *Promotoras* can also informally educate people on ways to help prevent the spread of disease and illness.

ADDITIONAL RESOURCES AND REFERENCES

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Bruhn, John G. and Brandon, Jefferey E. Border Health: challenges for the United States and Mexico, Garland Publishing, New York: 1997. (English only)

Varady, Robert G.; Mack, Maura D. Transboundary Water Resources and Public Health in the U.S.-Mexico Border Region. Journal of Environmental Health, April 1995: 8-15. (English only)

http://www.epa.gov/usmexicoborder/
The website of the U.S.– Mexico Border XXI Program ("*An alliance of organizations dedicated to environmental progress on the U.S. - Mexico border area, now and through the 21st century*") provides information in English and Spanish on border environmental health issues, including documents, maps, and links.

Environmental Committee of the Río Colorado Commission
This non-governmental organization serves the international area of Yuma, Arizona and San Luís Río Colorado, Sonora. It has various binational committees and works with air and water quality among other issues.

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Southeast Arizona Area Health Education Center (SEAHEC)
SEAHEC promotes public health in the border region through education programs and recruitment of health professionals. It works in areas such as environmental health diseases and water quality. SEAHEC has brochures and reports available.

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Subcomité de Salud y Medio Ambiente del Consejo Binacional de Salud de Ambos Nogales
This non-governmental organization promotes the cause of environmental health issues on both sides of the border and focuses on issues in the community that affect quality of life (such as water quality). It has articles and reports of environmental health research available.

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SOLID WASTE, CAN WE REALLY JUST THROW IT AWAY?

OVERVIEW OF THE ISSUE

Solid waste comes in many forms. It includes any type of household or business garbage (which is also known as municipal solid waste); refuse (e.g., metal scrap, wall board, and empty containers); sludge from waste treatment plants, water supply treatment plants, or pollution control facilities; non-hazardous industrial wastes (e.g., manufacturing process wastewaters and non-wastewater sludge and solids); other discarded materials from industrial and commercial activities (e.g., mining waste, oil and gas waste, construction and demolition debris, medical waste, agricultural waste); and household hazardous waste. Waste is considered *hazardous* if it is ignitable (i.e., burns readily), corrosive, or reactive (e.g., explosive). Waste may also be considered hazardous if it contains certain amounts of toxic chemicals.

Each year, people generate millions of tons of solid waste (trash) in every form. Durable goods (tires, appliances, furniture) and non-durable goods (paper, disposable products, clothing) account for several million tons of the solid waste stream. In the United States, people generate more trash than almost any other country in the world. From 1960 to 1990, the amount of garbage generated per person increased nearly 59%, from 2.7 to 4.3 pounds per person per day. European countries, such as Germany, Italy, Spain, Switzerland, the Netherlands, and the United Kingdom generate only around two to three pounds per person per day.

What happens to our trash? For hundreds of years, people disposed of solid waste by dumping in the open or burying it. There was even a time when cities disposed of their garbage in rivers or lakes. These methods worked for a while because most of the wastes consisted of biodegradable, organic compounds that easily decomposed. Municipal wastes became a problem with increased urbanization, generation of non-biodegradable garbage, and toxic wastes. Throughout the last century we have burned, buried (land filled), and even dumped our waste at sea. However, waste disposal has become a major environmental issue world wide not only because we are running out of places to "dump" our trash, but because of the very real health risks associated with our garbage. While earlier health risks included epidemics of yellow fever, cholera, small pox, and typhus, the health risks that exist today are due to the generation of toxins at garbage disposal sites and the transportation and disposal of hazardous wastes.

> Of the 209.7 million tons of municipal solid waste generated in the U.S. in 1996, over half (55.5% or 116.3 million tons) was land filled. Another 17.2% (36.1 million tons) was burned. Only 27.3% (57.3 million tons) was recovered for recycling, which includes composting.

Although the management of solid and hazardous waste is an issue world wide, here in the border region rapid industrialization and the associated increase of population have created a tremendous need for focus on this issue. Some of the specific border region waste issues that have been identified by federal and state agencies (as well as the general public) include the following:

- illegal cross border shipments of hazardous waste;
- improper disposal of hazardous and solid waste;
- health and environmental risks posed by inactive and abandoned dumping sites;
- proper development of new sites;
- proper operation and closure of existing sites.

Because many of our border communities are growing so rapidly, the problem of solid waste is also growing. More people typically means more trash. Our health, the health of our environment, and our visual landscape are all affected by this issue. Without proper planning and management, we run the risk of overwhelming ourselves in our own wastes.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Regardless of where one lives, we all contribute to and are affected by solid waste and hazardous waste—it is a very public issue. We would all like to live in a healthy, unpolluted environment. Some people are more affected by wastes due to their proximity to landfills or frequent exposure to hazardous waste (by occupation or location). Some people are very conscientious of their personal waste management while others simply throw their trash anywhere. Everyone is different yet everyone is affected.

In Mexico, the U.S., and on the Tohono O'odham Nation, there are specific agencies and organizations whose purpose is to regulate, manage, study or otherwise deal with solid and hazardous waste issues. These agencies monitor, regulate, and manage solid and hazardous waste in our countries. Additionally, they serve to educate people about the issue and support programs, which address the issue.

In Mexico, the Secretariat of Environment, Natural Resources, and Fisheries (SEMARNAP) is the primary agency dealing with environmental protection. Additionally, the National Ecology Institute (INE) is an autonomous agency of SEMARNAP and has under its authority the design of general environmental regulations and standards and the application of these regulations and standards through various mechanisms. Included among INE's various tasks are the "approval of programs and projects for the management of hazardous and solid wastes; control of transboundary movement of hazardous materials and hazardous wastes; and municipal solid waste policy."

In the U.S., the Environmental Protection Agency (EPA) is charged by Congress to protect the nation's land, air, and water systems. Under a mandate of federal environmental laws, the EPA "strives to formulate and implement actions that lead to a compatible balance between human activities and the ability of natural systems to support and nurture life."

On the Tohono O'odham Nation, there is a Solid Waste Office within the Natural Resources Department. This office oversees the Solid Waste Ordinance on the Nation and manages the collection and disposal of wastes. The office also educates the Nation's communities about the Solid Waste Ordinance and pollution prevention. In addition to the Natural Resources Department, the Nation's Environmental Office is also responsible for non-domestic hazardous waste management.

WORKING TOWARD RESOLUTION

In our border region, bilateral agreements ensure that our two countries coordinate and share information on hazardous and solid waste facilities along the border. Under the *U.S.-Mexico Consultative Mechanism for the Establishment of New Sites and for Existing Sites*, agreed to in June, 1992 by the U.S. and Mexico, both countries will continue to notify each other of proposed facilities "which store, treat, or dispose of hazardous, toxic, radioactive, or solid waste and which are required to be permitted, licensed, or approved by federal, state, or local authorities." Additionally, in March 1996, the Interministerial Group on Hazardous Waste Disposal Sites for the U.S.-Mexico border was formed in Mexico with the purpose of issuing joint statements on new hazardous waste facilities and to develop programs for compliance and monitoring of existing sites.

Another joint program working toward resolution of environmental issues in the border region is the Border XXI Program. Border XXI is a cooperative program between federal environmental agencies in the U.S. and Mexico (primarily the EPA and SEMARNAP). The mission of Border XXI is "to achieve a clean environment, protect public health and natural resources, and encourage sustainable development along the U.S.-Mexico border. "

In addition to federal programs, community efforts are perhaps one of the most effective ways of addressing the solid waste issue. New programs are being implemented throughout the border region to increase public awareness of the issues, to decrease the solid waste stream, and to better manage existing solid and hazardous waste problems. For example, in the communities of Ambos Nogales and in San Luis and San Luis Rio Colorado, grass roots environmental educators (also known as promotoras) are being trained to promote clean air and water. The promotoras will help educate local residents about the proper disposal of solid waste and toxic materials in the communities. On the Tohono O'odham Nation, the Solid Waste Department has hired an education coordinator who conducts outreach programs in the Nation's schools and communities to educate people about the new solid waste ordinance, recycling, and pollution prevention.

Solid waste is also important to address at the individual level. As most education campaigns emphasize, "reduce, reuse, and recycle" is the best strategy for managing our solid waste. This approach promotes source reduction first—meaning that people should first make an effort to reduce their consumption of items that generate garbage. This might mean buying in bulk

or buying items that require less packaging. The next part of this strategy is to reuse items as much as possible. Finding new and creative ways to use something can be a rewarding challenge. Finally, recycling is strongly encouraged. If your community does not have a recycling program, help promote interest in one and encourage your community leaders to implement such a program. If an item cannot be reused or recycled, only then should it be land filled.

Items such as oil, old paint, and pesticides are considered hazardous waste. Household hazardous waste should be disposed of only at a hazardous waste facility. Many communities provide hazardous waste collections on specific days of the year. Some students have even organized hazardous waste drop off days at their schools in conjunction with their local hazardous waste agencies.

People will likely continue generating trash as long as societies exist, as we know them today. While there are resolution strategies at all levels, it is very much up to every individual to make wise choices in the products they buy and how they dispose of their wastes. It is important to remember that while this is a very public issue regulated by federal policy and community programs, individuals can make a tremendous difference by both their consumer choices and their ability to influence their government, their community, and other individuals.

ADDITIONAL RESOURCES AND REFERENCES

Secretariat of Environment, Natural Resources, and Fisheries
This is the home page of SEMARNAP. Besides explaining the mission of SEMARNAP, it includes information on Mexico's natural resources, special programs, environmental protection, environmental education, environmental regulation, and sustainable development. *http://www.semarnap.gob.mx/*

Environmental Protection Agency – Border XXI Program
This is the homepage of the EPA's Border XXI program. It is accessible in both Spanish and English. Follow the links to the document "Border Environmental Indicators Report" to find additional information on solid and hazardous waste. To order copies of this report in the U.S., call 800-334-0741. *http://www.epa.gov/usmexicoborder/index.htm*
The Border XXI Program also has a Hazardous and Solid Waste Working Group.

Tohono O'odham Nation Solid Waste Management Program
The Tohono O'odham Solid Waste Management Program strives to better manage solid waste in the Tohono O'odham Nation. Education programs and other information are available for schools and communities located on the Nation. For more information contact:
Gary J. Olson, Manager
golson7691@aol.com

Faith Soto, Education Outreach Coordinator
P.O. Box 370
Sells, AZ 85634
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fax: (520) 383-5255

WATER USE

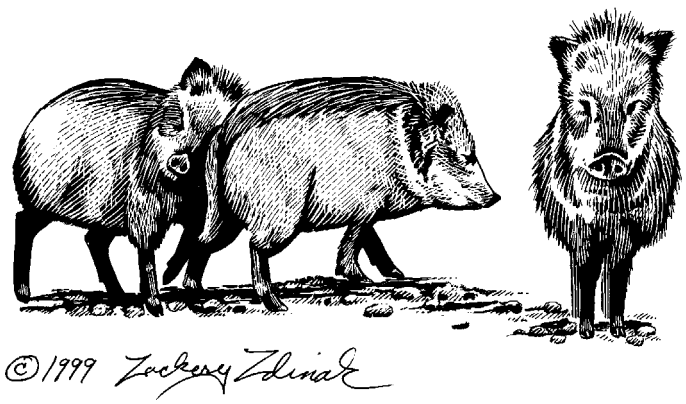
OVERVIEW OF THE ISSUE

Here in the Sonoran Desert, water is, and always has been, scarce. Prior to the 1930's the only water available for human use was surface water either from springs, seasonal or perennial rivers, or temporary pools. When the technology advanced to allow the digging of deep wells, human inhabitants of the desert were able to expand their activities in the region—building larger cities, establishing large agricultural practices, developing industries, and extending mining operations. Throughout the rest of the century, our communities continued to grow, as did our need for water. Unfortunately, our demand for water now exceeds the sustainable supply. While surface waters are dammed, diverted, and pumped beyond allotted amounts, groundwater pumping exceeds natural replenishment in most desert locations.

In the Arizona / Sonora border region our primary surface waters include the Colorado, Santa Cruz, and San Pedro river systems. These, as well as numerous tributary washes, cross the border through an arid environment shared by the U.S. and Mexico. The Rio Sonoyta, another border region river, originates on the Tohono O'odham Nation in Arizona and flows southward into Mexico, feeding a binational aquifer that supports a thriving agricultural area near Sonoyta, Sonora, just across the border from Organ Pipe Cactus National Monument. All these waters are shared among our countries.
Underground water (the region's major source of potable water) is also unaffected by political boundaries and the same underground basins often supply communities in both countries. In Nogales, Sonora, most of the city's water is drawn from two shallow well fields to the east (Mascarenas) and southeast (Paredes) of the city. These are augmented by a number of small wells within the city. The public water supply for Nogales, Arizona, is provided by two well fields just down gradient from the Mexican wells at Mascarenas and Paredes. Again, our environment, its natural resources (including water), and its dynamic processes do not respect human-created international boundaries.

The largest current water use in our region is agriculture. However, it is projected to decline, while municipal use is expected to double over the next 20 to 50 years. Southern Arizona and northern Mexico are among the areas with the highest population growth rates in the two respective nations. With an increase in population comes an increase in demand for water.
The standard of living and quality of life of those of us living in the Sonoran Desert are affected by the supply and demand of water. As an example, it is estimated that only 64% of residents in Nogales, Sonora are served with potable water. This number decreases as more people throng to that border city—the city's infrastructure cannot keep up with the growth. In many areas, the cost of water has increased because of increasing demand. Some regions are subsiding due to groundwater withdrawals. In addition to safety risks, this affects property values. In other areas, recreational activities are diminished when river flows are low and riparian ecosystems are damaged.

In addition to directly impacting human lives, water supplies affect the health of natural ecosystems. Before dam construction and water withdrawals, natural flows watered many important riparian and other wetland areas. Presently, much of what were natural flows are now captured and used long before reaching these habitats. The Colorado River delta is presently drying up and shrinking. This cuts off nutrients to the sea, reduces critical habitat for gulf fisheries, and is bringing ruin to the economic, social, and cultural life of local human populations. In addition, the Cienega de Santa Clara, the largest wetland bird habitat remaining in the delta, is sustained primarily by agricultural drainage water, an extremely insecure water supply. Riparian habitat along the Santa Cruz and San Pedro Rivers are also in peril as groundwater levels drop.



Continued reductions in our groundwater reserves would have several impacts on the region. As stated by one EPA Border XXI report, *"The water requirements of the mining industry, the Riparian National Conservation Area, municipalities, industry, military, and agriculture are all dependent on the same interrelated water source. The withdrawal of groundwater, the principal source of water*

supply for municipalities, industries, mining, and agriculture, is greater than the natural basin recharge." Direct impacts from groundwater overdraft includes land subsidence, higher costs associated with deeper wells, decreasing water quality in some areas as deeper waters are extracted, and ultimately, water shortages as wells fail. Lowering the groundwater table is also detrimental to riparian habitat.

The issue of water supply is perhaps the most critical of environmental issues in our desert region. All life is dependent on water. Our wise use of this resource means recognizing that it is a resource shared and affected by all residents in the region. Real, flowing water (either above or below ground) knows no political boundaries. We must all use it wisely today to ensure a supply for the future.

INTERESTED PARTIES AND INDIVIDUALS AND THEIR VIEWPOINTS

Everyone uses and needs water to survive. Water resource managers have categorized water users according to how the water is used. Typical water use groups include municipalities (for all community needs), agriculture, mining, industry, military, and recreation. Each user group feels their need is great and without water, they would be unable to continue their activities. This is indeed true for everyone who uses water.

In addition to water users, are the professionals who manage, study, and regulate water use. Hydrologists are scientists who study water. There are different areas of focus in the field of hydrology including groundwater, surface water, engineering, and water quality. Hydrologists are among the professionals who help us understand where and how water occurs and how to obtain it for various uses.

Other water-related professionals include those who work with water utilities companies. Water utility companies create and manage water treatment and delivery systems to bring potable water into our homes. A variety of hydrologists, chemists, engineers, and technicians contribute to this effort.

Another group of professionals dealing with water issues are natural resource managers. Because of the tremendous human need for water, natural areas and the vegetation and wildlife they support are often overlooked when water is allocated. However, there are a variety of habitats here in the desert whose entire existence depends upon an adequate water supply. Riparian areas, wetlands, and cienegas are examples of areas that must have water to support their ecosystems. Natural resource managers help monitor and maintain these areas and are quick to alert other scientists, the public, and policy makers when such ecosystems are jeopardy due to failing water supplies.

WORKING TOWARD RESOLUTION

Perhaps one of the most important steps toward resolution is for everyone (residents, policymakers, environmentalists, and competing business interests) to recognize the transboundry nature of water. Instead of staking claim to water resources on a particular side of the international border, it is very important for all citizens to realize that water is a shared resource that does not stay in one place. We must work to collaborate at all levels and manage water as the fluid resource it is. To that extent, the EPA / SEMARNAP Border XXI Water Work Group is making an effort to provide a framework for binational cooperation in the management of water. According to Irasema Coronado in her article *Water Conflict in the Borderlands* , "*Establishing truly meaningful region-wide and binational planning and management efforts as well as forums for discussion is a difficult, necessary task*. "

Another resolution strategy is to consider water-conserving alternatives in our homes and communities. According to Irasema Coronado "*At the local level, alternatives need to be explored, like shifting agricultural production to non-water intensive plants, switching from flood to drip irrigation and using treated household effluent in irrigation, industry, and facilities like golf courses and urban parks*. " Some communities are exploring these options and already have systems for reusing treated water. Citizens can encourage and participate in these water-conserving practices.

It is also crucial that we work cooperatively to raise our awareness of water conservation and the "complex challenges involved in sharing water resources." Education can play a key role in this endeavor. Some communities already have water awareness programs, often supported by the local water utility. By developing a consciousness about water issues and promoting the efficient and wise use of water, we can all contribute to water conservation efforts.

ADDITIONAL RESOURCES AND REFERENCES

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Unruh, J., and Liverman, D. *Changing Water Use and Demand in the Southwest*. Udall Center for Studies in Public Policy.

Borderlines
Borderlines is a monthly bulletin that provides in-depth, critical analysis of U.S.-Mexico border issues and the cross-border U.S.-Mexico relationship. It is published by the Interhemispheric Resource Center's (IRC) Border Information and Outreach Service (BIOS). Each edition of borderlines revolves around one specific topic, offering up-to-date information and analysis from knowledgeable experts and advocates, as well as the BIOS Action Kit, a directory of key contacts, internet resources, and background reading materials related to the month's topic. For more information or to obtain back issues contact*:*
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Arizona Water Resources Research Center
The center disseminates information on water issues in the border region. It maintains a database of water experts and has created a bilingual water quality-sampling handbook to support comparable data collection throughout the region.
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ISSUES INVESTIGATIONS FORM

Name: _____

1. Issue Overview. In your own words, describe your environmental issue:

_____

_____

_____

_____

2. Problems. List at least two reasons your issue is a problem.

_____

_____

_____

3. Affected parties. List at least three people (or parties) involved in this issue and describe how they are affected:

_____

_____

_____

_____

4. Resources. What particular natural resource does this issue affect?

_____

5. Measuring environmental change. Describe at least one way the resources affected by this issue might be scientifically measured and monitored. (*Note*: *This is not addressed in your case study so you'll need to consider how environmental change is measured*)

_____

_____

_____

6. Resolutions. List and describe at least two strategies that can help resolve this issue.

_____

_____

_____

_____

7. Other resolutions. Make up your own resolution to this issue and describe it:

_____

_____

_____

8. Contacts. Who else can you contact to get more information about this issue?

_____

_____

Extra Credit: Find at least one other source of information about this issue (You could use the "Additional Resources and Reference" section of your Case Study or any other source). Describe the information obtained from this source below, and share it with the class when you give your presentation.

STUDENT EVALUATION

Name_____ Class _____

List three human activities that are known to have long term effects on the landscape:

1. _____
2. _____
3. _____

Complete the sentence:

4. Prevention, eradication, control, and education are all strategies to work toward the resolution of _____ _____ species.

5. Circle the correct answer.

PM10 refers to:

a. pollution monitoring of water
b. particulate matter in the air
c. population measure of endangered species
d. permeability movement of water through soil

List three criterion air pollutants:

6. _____
7. _____
8. _____

Match each word with its definition by placing the correct letter of the definition in the space provided.

9. _____ particulate matter
10. _____ porosity
11. _____ hardness
12. _____ diversity
13. _____ pH
14. _____ ozone
15. _____ permeability
16. _____ abundance
17. _____ chlorine
18. _____ nitrate
19. _____ carbon monoxide

a. a measure of the concentration of hydrogen ions and indicates the acidic or caustic nature of your water
b. measure of the total amount of calcium and magnesium in water
c. measures the total number of individuals
d. a measure of dust, exhaust, smoke
e. occurs from incomplete combustion of fossil fuels
f. a secondary air pollutant formed when nitrogen oxides and hydrocarbons react in sunlight
g. describes voids or open spaces in soil
h. chemicals found in drinking water originating from farm fertilizer, industrial waste, sewage, biological waste, and feed lot run-off
i. sanitizing agent used by water treatment plants
j. measures the number of different kinds of something
k. describes the ability of water to move through soil

20. *Describe in detail two environmental issues that are relevant to our region. For each issue, you must include the following: 1. A description of the environmental issue; 2. Explain why the issue is a problem; and 3. Describe at least one potential resolution to this issue*.